TECHNICAL PROGRESS, FISCAL AFFAIRS, OBSOLESCENCE

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French tax structure with respect to write-off for scientific research and development, patent assignment and licensing, accelerated depreciation of equipment is described, with quotations from tax laws and sample questionnaires to be completed for exemption. Present and future impact of technical progress on national economy and world development is discussed and projected. Controversial opinions on allocation and tangible results of Government-sponsored and private R & D, between US and European economists are debated.

TECHNICAL PROGRESS, OBSOLESCENCE, AND EFFICACY OF REPLACEMENT INVESTMENTS */1

Ch.Sarthou

One frequently hears the expression "cost of obsolescence" defined as being losses produced by the obsolescence of productive equipment in the industrially most developed countries. The American Professor Mrozowski states that "industrial obsolescence abolishes the benefits of enterprise and the resources of the State". It is entirely natural that the invalidation of equipment, still in perfect condition, is generally considered as a waste imposed by the constraints of a ruinous competition.

However, obsolescence is a necessary correlative of technical progress, of which no one will deny the ultimate benefit. Thus, a definite incompatibility

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* Numbers in the margin indicate pagination in the original foreign text.

exists between the belief that technical progress is the motive power of economic progress and the feeling that the "cost of obsolescence" leads to the ruin of both enterprises and State.

The object of this particular report is to remove this apparent contradiction and to demonstrate that the reduction in life of the equipment, as a consequence of the acceleration of technical progress, by no means reduces the revenue of the State, of enterprises, and of individuals and that, quite on the contrary, everyone would lose if the service life of the equipment would be prolonged beyond a certain point at which the total production has reached its maximum volume.

Taking exactly the opposite viewpoint of the general feeling with respect /2 to the term "obsolescence cost", we are much more inclined to define this type of cost as the loss produced by maintaining certain equipment in service beyond the above point.

To come to this result, it was necessary to construct a general price model which, in the meantime, has permitted clarification of some rather obscure questions and, in particular, a definition of what we consider absolute and relative efficacity of investment.

From the practical viewpoint, this latter result seems the most important. In the economic management of enterprises, the annual balance sheet represents the instant of truth. These balance sheets reflect the yield of the entire invested capital or what we call its absolute efficacity.

However, it is difficult - not to say impossible - to give a separate definition of the yield of capital allotted to the replacement of a given piece of equipment, since this type of capital frequently constitutes only an infinitesimal portion of a complex conglomerate of which only the total yield can be con-

verted into figures. In this case, one is usually satisfied with calculating the relative yield of such capital investments, i.e., with a comparison of the costs resulting from the ex-ante situation, if the latter was maintained, and of the cost after replacement.

It would seem that this relative yield should be of the same order of magnitude as the normal yield of capital invested in that particular branch of business. However, the model constructed by us indicates that these two yields are of an entirely different nature. In fact, they are actually diametrically opposed, i.e., the relative yield is higher the lower the normal yield of the particular industry.

The repercussions of this result on the policy of replacement of equipment and on losses that might result from certain decisions taken, such as those /3 referring to interest rate of invested capital, are quite obvious.

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I. PHYSICAL AND HUMAN DETERMINANTS OF ECONOMIC GROWTH 4

I.1 The Three Phases of Economic Development

In the first phase of industrialization during which takes place the transition from artisan economy to industrial economy, the traditional and individual instruments of production are progressively replaced by equipment of incomparably greater yield. In modern industrial nations where this transition has taken place over relatively long periods of time, the problem of the manpower necessary for exploiting this equipment has never been extremely acute. The indispensable work units were formed in response to the requirement, and unskilled labor was naturally taken from the large reservoir represented by the farming population. The economic growth during this phase was uniquely conditioned by the capacity of a given country to produce new equipment, which immediately was matched with available labor force. This means that, beyond the phenomenon of competition which required a certain development of production techniques but which should not be overestimated in importance, there was no incentive for business enterprises to renew the equipments before they had reached their point of normal wear. This constituted a period of pure extension of productive

capital. New arrivals in the market did not battle their predecessors, since sufficient reserves of manpower were available.

The second phase started at the moment at which the reserves began to become exhausted and at which the migration from the farm to cities started slowing down. A portion of the effectives allotted to new equipment are effectives liberated by the replacement or invalidation of used material that physically was incapable of ensuring continuance of normal industrial service. However, /5 if the aptitude of a given economy for investment exceeds the quantity of used equipment, i.e., if a positive net investment is present, the monies necessary for exploiting this positive investment balance must be liberated by discarding the oldest equipment before complete wear. It is this investment surplus, with respect to the strictly necessary measures for preserving a constant capital stock, that determines the growth of economy. However, with respect to the first phase, the yield decreases and the expansion rate slows down since we no longer have to do here with a pure capital extension and since the total volume of investment is absorbed only under the condition that equipment still in good working condition is obsoleted, which would be senseless unless, in the meantime, technical progress had taken place.

During the third phase, known as the maturity phase, the preceding process has come to an end and the importance of technical progress assumes its total significance. The entire equipment is replaced before being worn out, and the growth depends only on the technical progress itself. This is an economy, in this phase of development, which we will now represent by a model.

I.2 Growth of an Economy, Arrived at Maturity

Below, we will discuss the phenomenon of growth of an economy, character-

ized by two sectors which, respectively, produce consumer goods and production implements. The production functions of these sectors are assumed to be homogeneous Cobb-Douglas functions of the first degree. To avoid tedious calculations, the functions of the two sectors are assumed to be identical so that the total production of the economy is given by a function identical to those of each of the sectors.

If T denotes the total quantity of available homogeneous work (in this /6 study, T will represent a manpower effective assumed to be homogeneous), and if C denotes the capital counted in physical units exploited by the work T (if the economy produces only one type of tools, C will represent the number of available tools; if not, C will represent a measure of the total available capital stock), then the volume of production P, obtained by combining C and T, is given by the Cobb-Douglas relation

$$P = A\, C^{\alpha}\, T^{1-\alpha}$$

where α is a constant and A is a coefficient that depends on the selected units. For a suitable selection of units, we can pose A = 1 and

$$P = C^{\alpha}\, T^{1-\alpha}\ .$$

The technical progress, at any instant, increases the productivity of labor. If this technical progress is neutral, it will act like a time-variant coefficient of the production function. If the relative growth, due to technical progress, of the production volume obtained at given capital and labor is constant, this coefficient will be given by the function $e^{\pi t}$ where π represents the technical progress and t the time so that, if C_t represents the invested capital at the instant t during unit time and if T_t represents the work allocated to this capital, then the resultant production will be

$$P(t) = e^{\pi t} C_t^{\alpha} T_t^{1-\alpha} \qquad (1)$$

This production formula presupposes that a substitution exists between capital and labor since no supplementary relation exists for defining the ratio of C_t to T_t. However, this substitution exists only ex-ante. In planning a given piece of equipment, it usually is conceived as a function of the labor available for operating this particular equipment. We will assume that, once the equipment has been constructed, this substitution is no longer permissible and that it must then operate with a constant effective during its entire useful life. This may also mean that this equipment will not be modernized during its lifetime, and that new production techniques can be introduced only by /7 means of entirely new equipment.

This manner of proceeding, which we take from L.Johansen (Bibl.1), yields an answer to most of the objections raised against the use of production formulas, which reduces to the following: Because of technical progress, the implements constructed at various epochs are not identical, and the production function statistically defined over a certain period of time represents an amalgamation of heterogeneous data. [For a discussion on this point, see Kaldor (Bibl.2).] In fact, the possibility of a capital - labor substitution at a given instant is generally considered a combination of these two factors, yielding a production connected to the volume of the two factors over a certain function. The only point which remains open to discussion is that of the form of this function. We have retained a homogeneous function of the first degree, as has been done by most of the authors who were concerned with problems of this type, because of the extreme simplicity of the calculations involved. As soon as one gets away from this formula, considerable difficulties will be encountered.

We will assume that, at any instant, full use of capital and available

labor is present and we will disregard here, in a "normative" model, the mechanisms and the behavior of producers and consumers by which this result can be reached.

Total utilization of manpower and capital resources obviously must be /8 the primary objective of any effort made in the organization of economy, and the observation of European industrialized nations indicates that this objective can be practically attained in the expansion phase.

The invested portion of the national revenue is supposed to be constant. This again is a statement in fact, insofar as the postwar European economies are concerned. The mechanisms that ensure this constancy of investment are highly complex but can be roughly explained by stating that the portion of the public sector in the total investment is relatively large (of the order of 50%) and that it is thus obvious that government agencies will play a regulatory role.

Finally, the rate of growth of the available labor force, i.e., the total effective, will be assumed as constant and independent of economical factors.

We will consider an economy in which the life of the equipment is fixed and constant in time. Since we are living in an ecoromy that has reached maturity, this life is an element of choice since it is shorter than the physical lifetime. We will introduce this factor into our general model as a parameter.

If D denotes this lifetime, the available effective T_t per unit time for the capital C_t invested per unit time at the instant t will be the sum represented by the monies or effective liberated by obsoleting the equipment that has reached the age D plus the fraction of the population that reaches the age of activity at the instant t.

If θ denotes the rate of demographic growth and if $\overline{T}_0$ is the total active /9 population at the instant taken as the origin of time, the effective of the

total population at the time t will be equal to

$$\overline{T} = \overline{T}_o \, e^{\beta t}. \tag{2}$$

The effective reaching the age of activity per unit time is equal to

$$\frac{d\overline{T}}{dt} = \overline{T}_o \, e^{\beta t}.$$

The effective liberated per unit time by replacement of the equipment of age D is T(t - D).

Thus, we have

$$T(t) = T(t-D) + \beta \overline{T}_o \, e^{\beta t}. \tag{3}$$

The solution of this equation has the form $T_o e^{\beta t}$. By substitution into eq.(3), we obtain the value of T_o

$$T_o = \frac{\overline{T}_o \, \beta}{1-e^{-\beta D}}. \tag{3a}$$

Let us also stipulate that $\overline{T}_o$ represents the total active population at the instant taken as the origin of time, while T_o represents the fraction of the available effectives allocated to the new investments placed into service at the instant zero.

Let C(θ) be the volume of the capital invested per unit time at the instant θ. Let us pose

$$C(\theta) = C_o \, e^{\sigma \theta}. \tag{4}$$

The production obtained per unit time, during the entire lifetime D of /10 the capital, in virtue of eq.(1), will be

$$P_\theta(t) = e^{\pi\theta} \left(C_o \, e^{\sigma\theta}\right)^\alpha \left(\frac{T_o \, \beta}{1-e^{-\beta D}} \, e^{\beta\theta}\right)^{1-\alpha} \tag{5}$$

or else

$$P_\theta(t) = C_o^\alpha \, T_o^{1-\alpha} \, \frac{\beta^{1-\alpha}}{\left(1-e^{-\beta D}\right)^{1-\alpha}} \, e^{\{\pi+\alpha\sigma+(1-\alpha)\beta\}\theta}$$

for $\theta \leq t \leq \theta + D$.

The total production $\overline{P}(t)$, at the instant t, is the sum of the production of invested capitals during the entire lifetime t - D, t. We then have

$$\overline{P}(t) = \int_{t-D}^{t} P_\theta(t)\, d\theta .$$

Thus, from eq.(5) it follows that

$$\overline{P}(t) = C_o^{\alpha}\, \overline{T}_o^{1-\alpha}\, \frac{\beta}{\varepsilon}^{1-\alpha}\, \frac{(1-e^{-\varepsilon D})}{(1-e^{-\beta D})^{1-\alpha}}\, e^{\varepsilon t} \qquad (6)$$

where*

$$\varepsilon = \pi + \alpha\sigma + (1-\alpha)\beta . \qquad (7)$$

Since the investment represents a constant fraction of the total product, its rate of growth will be equal to ε. Thus, we have $\sigma = \varepsilon$ and, according to eq.(7),

$$\varepsilon = \frac{\pi}{1-\alpha} + \beta .$$

If i denotes the fraction of the total invested product, we have

$$C(t) = i\, \overline{P}(t). \qquad (8)$$

Posing $\Phi = \beta \overline{T}_o$, $\Psi = 1 - e^{-\varepsilon D}$, $\Omega = 1 - e^{-\beta D}$, we can derive from eqs.(7) /11 and (8):

$$\frac{C(t)}{i} = \frac{C_o}{i}\, e^{\varepsilon t} = C_o^{\alpha}\, \frac{\Phi}{\varepsilon}^{1-\alpha}\, \frac{\Psi}{\Omega^{1-\alpha}}\, e^{\varepsilon t} . \qquad (8a)$$

Hence,

$$C_o = \left(\frac{i\Psi}{\varepsilon}\right)^{\frac{1}{1-\alpha}} \frac{\Phi}{\Omega} .$$

Substituting this value of C_o into eq.(6) will yield

$$\overline{P}(t) = i^{\frac{\alpha}{1-\alpha}} \left(\frac{\Psi}{\varepsilon}\right)^{\frac{1}{1-\alpha}} \frac{\Phi}{\Omega}\, e^{\varepsilon t}. \qquad (9)$$

From this expression for $\overline{P}(t)$, which is the total physical production of

* This formula is due to Benton F. Massel (Bibl.3).

the economy at the instant t, we can draw important conclusions.

I.3 Role of Technical Progress in the Growth

The rate of growth ε is independent of the volume of investment and of the lifetime D of the equipment, which does not figure in the expressions Ψ and Ω. This rate depends only on the technical progress and on the demographic growth. The technical progress influences the economic growth over the multiplier $\frac{1}{1-\alpha}$.

However, this conclusion must be somewhat moderated in that it is slightly too absolute. Recent investigations by J.Schmookler (Bibl.4, 5) have shown, contrary to common expectations, that the inventive activity within a given industry producing production implements, follows rather than precedes the investment. Statistical series have demonstrated that the share of invention /12 in these industries is directly proportional to the volume of investment. In fact, enormous differences in investment are encountered, depending on the individual industrial branches and the enterprises within one and the same branch, which leads us to believe that the above-mentioned work assumes its greatest value at the level of the enterprise. However, within the framework of a model intended to demonstrate a certain number of logical relations (others than that we have mentioned), the fact that technical progress is independent of the volume of investment can be accepted as true more readily as the value of i varies little for most of the industrialized nations. Let us assume that i fluctuates between 13 and 20% for nations of capitalistic structure. For planned economies, the value of i does not exceed 25%.

This very simple model reflects the results of recent empirical studies (Bibl.6, 7) in which the thesis is defended that the increase in national pro-

ducts of the USA over the last 40 years is largely due to the combined progress in technology and economic organization. According to Solo , the percentage of this type of progress is of the order of 80% while only 20% of the growth is attributed to an "extension" of capital.

I.4 Existence of an Optimal Life of Equipment*

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Equation (9) indicates that the lifetime of equipment will enter over Ψ and Ω only in the coefficient of the growth term $e^{\varepsilon t}$. Thus, this lifetime does not influence the growth but rather the level of production; this level reaches a maximum for a given value of i, simultaneously with the ratio $\frac{\Psi^{1/1-\alpha}}{\Omega}$. Thus, there exists an optimal value for the lifetime of equipment for which the yield of economy is maximum, other conditions being equal. For values of α, β, and π equal, respectively, to $\frac{1}{3}$, 0.01, and 0.03, this ratio reaches its maximum for D = 14 years at which time its value will be equal to 3.30. For the same values of α and β but at π = 0.05, the maximum will be reached at D = 10 years, and the value of this ratio will be equal to 4.32. In the first case (π = 0.03), the rate of growth is equal to 6% while, in the second case (π = 0.05), it will be equal to 8.5%. Consequently, of two economies investing the same portion of the national income, that economy showing the greatest rate of growth in technical progress produces most at any instant, even if such superior rate of technical progress is accompanied by a more rapid obsolescence and thus by a shorter life of the equipment. This demonstrates clearly that the opinion, rather widespread in the USA** according to which the acceleration of the phenomenon of obsolescence,

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* The existence of an optimal lifetime of the equipment has been revealed by Benton F.Massel in his article published in Econometrica.

** We refer to the statement by Terborgh, cited by Saint-Paul (Bibl.8): "Technical progress and modification of demand combine to intensify the (cont'd)

consecutive to technical progress, will end up by ruining the American nation, lacks any basis in fact. We will return to this point later.

I.5 Existence of an Optimal Investment Rate /14

Equation (9) also shows the influence of the rate of savings i (or of investments) on consumption. The volume of consumption is equal to

$$(1-i)\ \bar{P}(t) = (1-i)\ i^{\frac{\alpha}{1-\alpha}}\ \left(\frac{\psi}{\varepsilon}\right)^{\frac{1}{1-\alpha}}\ \frac{\phi}{\Omega}\ e^{\varepsilon t}. \qquad (10)$$

The volume of the consumed production will reach a maximum at any instant, provided that the expression

$$J = (1-i)\ i^{\frac{\alpha}{1-\alpha}}$$

is maximal, i.e., provided that we have

$$\frac{dJ}{di} = \frac{1}{1-\alpha}\left(\alpha i^{\frac{2\alpha-1}{1-\alpha}} - i^{\frac{\alpha}{1-\alpha}}\right) = 0,$$

i.e., $i = \alpha$.

The question of the existence of an optimal investment rate has resumed actuality due to a recent article by J.Tinbergen (Bibl.9). After having stated that, over long periods of time, the western nations have invested 12% of their revenue whereas the communist countries generally invest 25%, the author raises the question whether it is possible to define the optimum rate by methods of econometry. The principle used by him for solving this problem consists in

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* (cont'd) aggression by the new on the old, constituting a banditry without bloodshed by which capital is deprived of its function". On the other hand, Dr. Mrozowsky mentioned that "after the impact of the present effort in research and development, the American economy may run the risk of no longer being able to support the induced growth of the rate of obsolescence" and that, in addition, "the industrial obsolescence abolishes the gain of enterprises and the resources of the State".

defining the investment rate that maximizes the sum of benefit allotted to consumption. If the profit gained from goods available for consumption at the instant t is a function U(i, t), where i is the rate of investment, then /15 $i(t)_{opt}$ is defined by the functional relation

$$U = \max_{i\,(t)} \int_c^{\infty} U(i,t)dt. \qquad (11)$$

The results obtained under the various hypotheses are identical. The values resulting for the optimal rate of investment are extremely high. They tend to indefinitely keep the consumption to the absolute minimum for subsistence and to relegate to a constantly pushed out tomorrow the consumption for personal benefit of goods produced by the accumulated capital. This result which, if it were applied, would make the western nations "more communist than the communists" according to the expression by Tinbergen (given in French within the text), is considered by our author as constituting a distinct failure. One important element is missing for a simple maximizing of instantaneous benefit. Boiteux, who picked up this question, introduced a "psychological discount rate" and demonstrated that an optimum investment rate will be obtained if this psychological rate is maintained within narrow limits. However, most economists, including Tinbergen, did not believe themselves able to overcome their difficulties by basing themselves on this notion since, according to their opinion which we share fully, the degree of preference of individuals for immediate satisfaction cannot possibly rule the decisions made at the level of the State.

It is necessary to differentiate two basic moments, if one wishes to see clear in this question. The first of these moments corresponds to the first phase of economic growth, of which we talked above. The second moment has to do with an economy that has attained maturity, the case treated in our model.

For a matured economy, the limitation of the manpower effectives results in

a decreasing yield of the invested capital while its volume actually increases. There comes a moment at which the production surplus, obtained by the supple- /16
mentary investment, is just exactly equal to this investment. If one passes beyond this point, the surplus will become inferior to the invested capital and there will be a reduction in consumable revenue. Thus, this point represents the optimum investment policy, which is exactly that defined by eq.(11). In France and in European countries that invest about 17% of their national revenue, one is not far from this point. However, it must be emphasized that this is by no means due to a deliberate choice by either consumer or manufacturer. The history of social struggle and social claims, the necessity of reducing these claims so as to prevent an excessive inflation rate, and the limitation of credit to consumption are all facts which demonstrate that the consumption volume reached - and, consequently, the rate of investment realized - do not correspond to the wishes and desires of the consumer who, left to his own devices, would no doubt consume a much larger portion of the national revenue. If, now, one turns to the manufacturer it is obvious that his choice is also not guided by a "psychological discount rate" but rather by the necessity that, for survival, he must further develop and claim a constant part of the market. This automatically means further investment.

Although, because of the limitation of effectives, there exists a maximum of investment rate which cannot be exceeded without reducing the volume of present and future consumption, this holds true only for an economy that has arrived at maturity.

This still does not settle the question with respect to the first phase of industrialization, defined above. It is obvious that this phase will be /17
shorter the greater a portion of the national revenue is invested. However,

physical as well as social restrictions limit the realizable rate of investment. Primarily, the wages cannot be maintained at the subsistence level. The mean wage level must increase constantly. In fact, an accelerated industrialization requires an increasing number of qualified technicians, and an open spread of wages is the best incentive for the formation of cadres. The example of the USSR proves this most adequately. Finally, as mentioned by Branks Horvath (Bibl.10), there exists for any country, even in the first phase of development, an investment rate that cannot be absorbed by the economy and beyond which the marginal efficacity of investment becomes negative. B.Horvath believes that, for numerous countries, the rate of investment is of the order of 30%, which could result in a growth of the order of 10%. The investment limits are imposed by the capacity of absorption of the economy, which - in turn - is fixed by the scientific and technical formation of necessary cadres and, in a general manner, by the state of the art and the dissemination of knowledge, as well as by the political and economic status of the organization.

Let us mention finally that the concept of psychological discount rate is even less acceptable here than for an economy in its period of maturity. It is obvious, if one has studied at all the history of accumulation in countries in the course of industrialization, that such accumulation is not the result of decisions of individuals based on their degree of preference for future satisfactions. Rather, such accumulation has taken place during the 18th and 19th Century (speaking only of the Western European nations) under extremely austere conditions of the salaried masses: 12-hour days and more, no vacation periods, wages that hardly met the bare subsistence level, unemployment resulting from /18 too intense periods of accumulation, sweatshops in which children of 14 years and less were made to work. The history of the working class struggle during

this era demonstrates clearly that this situation was by no means tacitly accepted even if it was an absolutely indispensable condition for having future generations enjoy an incomparably better situation, such as it exists today.

II. PRICES, COST, AND EVOLUTION OF WAGES

II.1 Prices

If, as done in the classical theory of ideal competition, it is stipulated that competition progressively eliminates all profits, the price system would be automatically determined as soon as the wage scale is fixed. However, competition may be more or less strong, depending on the structure of concentration of the various industrial branches that comprise the national economy. If the competition is "weak", a certain profit rate will exist and the price system will then have two degrees of freedom. This is defined only if, in addition to wages, the profit rate is fixed, as demonstrated by M.Morishima (Bibl.11) on a general model, in which he assumed that the "weak" competition, even if it does not do away with profit, will level it out over all industries. This means that he used a unique profit rate from which, based on fixed wages, he derived the price system for each particular industry. This institution of a single profit rate does not correspond to industrial reality where widely differing profit rates are encountered, depending on the various branches and on the individual firms within a given branch.

Our analysis is limited to a two-sector economy characterized - as mentioned above - by functions of identical production. /19 Instead of using the profit rate as the determining parameter, together with wages and price levels, we will use the distribution of consumption between the revenue of labor and the revenue of capital. This manner of proceeding has the advantage of clarify-

ing several points. If the part played by capital income in the consumption is zero, this would mean that - properly speaking - no profit is present since any capital income is immediately reinvested in the production process. However, this hypothesis is difficult to sustain in an economy controlled by individual initiative since, no matter what the degree of competition might be, capital is always invested for the purpose of withdrawing, sooner or later, a profit in the form of consumption or goods for personal use. This consumption or this possession will determine the rate of profit and, by this, the efficacity of the invested capital.

In this study, we will always reason in terms of efficacity of capital, a concept which will be further defined in the next Section. Efficacity of capital is a concept which does not differ from the term of "interest rate" used by most economists who have studied these questions (Morishima, Malinvaud, Allais, and others), but we personally prefer to reverse the term "interest" to designate the lending and borrowing of money.

It will be assumed that the wages are not saved, i.e., that, at each instant, they consume the entirety of their revenue. We could have introduced, as is generally done, a wage savings function but such a complication changes nothing in the results of the analysis. In fact, the saving of wages hardly ever is directly invested in the production process. In most cases, this constitutes only a forced saving, over the intermediary of credit system of con- /20 sumption. Consequently, this savings function shows up only in the slope of the demand curve and in the modification of the distribution of consumed revenue, since the interest shed out for the consumption credit returns to the holders of the capital. Here, we will use a priori - in an economy that has reached its "golden age" - the overall demand and the consumption relative to the capital

revenue, without worrying whether these revenues partially originate in the mass of wages paid.

Since the industries producing equipment goods and the industries producing production goods are subject to the same production function, there is no possibility of differentiating, a priori, the prices of these two types of industries.

Finally, assuming that the prices are constant, because of the fact that our economy invests a constant portion i of the total revenue, and that the production increases at the rate ε, this would mean that the total mass of wages increases at the same rate. If W(t) denotes the individual wage at the instant t, then the total mass of the wages, at a total effective equal to $\overline{T}_o e^{\beta t}$, will be

$$\overline{W}(t) = W(t)\ \overline{T}_o e^{\beta t}. \tag{12}$$

Since, under the hypothesis of constant prices, W(t) increases at a continuous rate ε, we have

$$\overline{W}(t) = \overline{W}_o\ e^{\varepsilon t} \tag{13}$$

where $\overline{W}_o$ is the total mass of wages at the original instant. From eqs.(12) and (13), we derive

$$W(t) = \frac{\overline{W}_o}{\overline{T}_o}\ e^{(\varepsilon-\beta)t}.$$

Since we have two degrees of freedom for fixing the price system, we will start from unit wage at the origin of time. Then, /21

$$\overline{W}_o = \overline{T}_o$$

and

$$W(t) = e^{(\varepsilon-\beta)t} \tag{14}$$

$$\overline{W}(t) = \overline{T}_o\ e^{\varepsilon t}. \tag{15}$$

The volume of consumption, at any instant, is equal to

$$(1-i)\ \overline{P}(t)$$

where $\bar{P}(t)$ is given by eq.(9).

If R_c denotes the share of the capital revenue in the total consumption, the consumption of wages, in volume, will be

$$(1-R_c)(1-i)i^{\frac{\alpha}{1-\alpha}}\left(\frac{\psi}{\varepsilon}\right)^{\frac{1}{1-\alpha}}\frac{\phi}{\Omega}\ e^{\varepsilon t}$$

while its value will be equal to the mass of wages $\bar{W}(t)$ given by eq.(15). Thus, the price per unit product will become

$$p = \left((1-R_c)(1-i)i^{\frac{\alpha}{1-\alpha}}\ \beta\left(\frac{\psi}{\varepsilon}\right)^{\frac{1}{1-\alpha}}\right)^{-1}\ \Omega\ . \qquad (16)$$

II.2 Receipts and Production Cost of Enterprises

To evaluate the situation of enterprises, we will use the classical artifice which consists in assuming that the economy is constituted of enterprises having the same behavior and being totally vertically integrated with respect to the production of materials necessary for their operation, of which the only two expense items are the acquisition of production implements and the payment of wages; these latter will constitute the only current expense item of exploitation.

For each enterprise, the balance relative to the investment realized at /22 the time θ, at each instant, will exactly reflect the balance of all enterprises that have made investments at the same time θ. Thus, it will be sufficient to establish one general balance sheet.

The volume of investments realized at the time θ, per unit time, in accordance with eqs.(8) and (8a) will be

$$C(\theta) = \left(\frac{i\psi}{\varepsilon}\right)^{\frac{1}{1-\alpha}}\frac{\phi}{\Omega}\ e^{\varepsilon\theta}\ . \qquad (17)$$

To these investments there corresponds an effective [see eqs.(3) - (3a)] of

$$T(\theta) = \frac{\Phi}{\Omega} e^{\beta\theta}$$

whose cost, in wages, is equal to the time t at $W_\theta(t) \cdot T(\theta)$, i.e.,

$$W_\theta(t) = \frac{\Phi}{\Omega} e^{(\beta\theta+(\varepsilon-\beta)t)} \tag{18}$$

or, if d represents the age of the equipment placed into service at the time θ, we have $t = \theta + d$ and

$$W_\theta(t) = \frac{\Phi}{\Omega} e^{\varepsilon\theta+(\varepsilon-\beta)d}.$$

This investment and this manpower, when combined, yield the time-invariant production volume per unit time over the entire duration θ, $\theta + d$:

$$P(\theta) = (C(\theta))^{\alpha} (T(\theta))^{1-\alpha} e^{\pi\theta} = \left(\frac{i\psi}{\varepsilon}\right)^{\frac{\alpha}{1-\alpha}} \frac{\Phi}{\Omega} e^{\varepsilon\theta}$$

of a value of $p \cdot P(\theta)$, i.e.,

$$V(P(\theta)) = (\beta\cdot\psi (1-R_c)(1-i))^{-1} \varepsilon\cdot\Phi e^{\varepsilon\theta}. \tag{19}$$

Then, the ratio of the production value to the wages will be

$$\frac{V(P(\theta))}{W_\theta(d)} = (\beta\psi(1-R_c)(1-i))^{-1} \varepsilon\Omega e^{(\beta-\varepsilon)d}$$

This ratio is independent of θ, which is the date of placing the investment in work, and depends only on its age. Thus, it is sufficient to study the phenomenon over a single period, for which we will select $\theta = 0$. For the investment, realized at the time $\theta = 0$, we have /23

$$W_0(d) = \frac{\Phi}{\Omega} e^{(\varepsilon-\beta)}$$

$$V(P(0)) = (\beta\psi(1-R_c)(1-i))^{-1} \varepsilon\Phi$$

These expressions indicate that, whereas the production has a constant value, the wages paid for the constant effective, ensuring this production, in-

crease exponentially with the rate $\varepsilon - \beta$. The exploitation benefit is progressively reduced, leading to a moment at which the wage expenditure (current expense) will exceed the receipts. This moment depends on the value of R_c.

For example, for the adopted values of $\alpha = \frac{1}{3}$, $\beta = 0.01$, $\varepsilon = 0.06$, and for $\overline{T}_o = 100$, using the optimum value of 14 years for D, we obtain

$$T(0) = 7,657 \qquad W_0(d) = 7,657\ e^{0.05d}$$
$$V(P(0)) = 13,187\ (1-R_c)^{-1}.$$

For $R_c = 0$, i.e., if no profit is drawn from the capital (at each instant, the totality of the capital revenues are reinvested, which would be characteristic for operation of a communist economy or for a capitalist economy in ideal competition in which the wages are not saved), the ratio

$$\frac{V\ P(0)}{W_0(d)} = \frac{13,187}{7,657}\ e^{-0.05d}$$

is equal to 1, i.e., the production cost is equal to the receipts, for

$$e^{0.05d} = \frac{13,187}{7,657} = 1,722$$

i.e., for d = 11 years. Since the optimum lifetime of the equipment is 14 years, the enterprises, in this economy under optimum management would have to op- /24
erate at a loss during 20% of the time.

This constitutes the justification for a nonexplicit postulate by S.G. Stroumiline (Bibl.12) according to whom, in a "socialistic" economy, all business enterprises would have to operate for a certain time at a loss so as to give themselves a chance to await the latest technical progress, in which case the losses at the end of the period would be compensated by the resultant advantage of having a more productive equipment. This viewpoint would have to be somewhat modified since all enterprises, even of the socialistic type, must maintain adequate production to ensure operation of government agencies, health services,

national education, armed forces, and indirectly productive services whose consumption must be placed into the category R_c. However, we will not further pursue this topic since it would go beyond our subject matter.

Figure 1 shows the situation of receipt and cost as a function of R_c during successive renewal periods of equipment, for a given production value, using the parameters of the preceding example. This diagram indicates that the excess of receipts over expenses at the end of the optimal exploitation period, depends on the value of R_c, i.e., on the respective shares of wages and capital in the consumption or on the rate of gain of the enterprise in question. Conversely,

/25

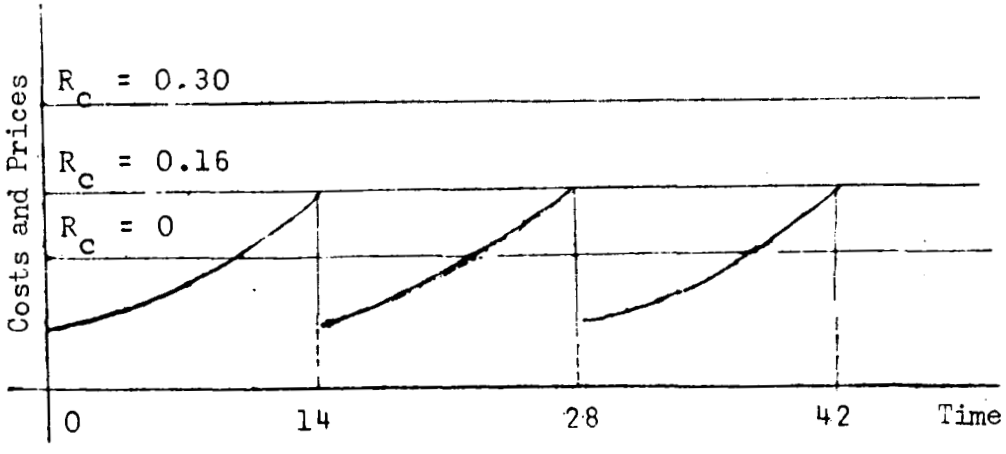


Fig.1 Cost of Production and Receipts for a Production of Constant Value, during Successive Periods of Equipment Renewal

the reduction in operating cost by renewal of the equipment is totally determined by the physical data of the economy; it is obvious that the optimal lifetime can be accurately defined (no matter at what distribution of the product which is a sociological datum) by the difference between the production cost of the equipment to be obsoleted and the production cost of the equipment replacing it.

II.3 Ratio of Capital to Production (Capital - Output Ratio)

The volume $C(\theta)$ of the capital invested at the instant θ, given by eq.(17)

$$C(\theta) = \left(\frac{i\Psi}{\varepsilon}\right)^{\frac{1}{1-\alpha}} \frac{\Phi}{\Omega} \quad e^{\varepsilon\theta}$$

when exploited by the manpower effective /26

$$T(\theta) = \frac{\Phi}{\Omega} \quad e^{\beta\theta}$$

will produce, in volume, at any instant $t(\theta \leq t \leq \theta + D)$,

$$P_\theta(t) = \left(\frac{i\Psi}{\varepsilon}\right)^{\frac{\alpha}{1-\alpha}} \frac{\Phi}{\Omega} \quad e^{\varepsilon\theta}. \tag{20}$$

From these relations, we derive the value of the ratio

$$\frac{C(\theta)}{P_\theta(t)} = \rho$$
$$\rho = \frac{i\Psi}{\varepsilon}. \tag{21}$$

Since, in our model, the price per unit product and that per unit capital are equal, the quantity ρ will also represent the ratio of the value of the capital to the value of the output.

It is obvious that this ratio is constant in time. This result, which should not be surprising since we have accepted the hypothesis of a neutral technical progress for the entire economy, requires further explanation. Let us note that the volume of the capital per unit manpower

$$\frac{C(\theta)}{T(\theta)} = \left(\frac{i\Psi}{\varepsilon}\right)^{\frac{1}{1-\alpha}} e^{(\varepsilon-\beta)\theta}$$

generally increases with the time since, for an economy in expansion, we have $\varepsilon > \beta$. Each labor unit thus has an increasing quantity of materiel at its disposition. However, in an economy which invests a constant portion of its total revenue, the excess of consumer goods resulting from the growth can only be

absorbed, at constant prices, by an increase in wages. This increase must be such that, taking the demographic growth into consideration, the total mass of wages in each of the industries constituting the economy, will represent - at each instant - a given fraction of the production.

Let us also note that the ratio ρ does not depend on the distribution of /27 the consumption between capital revenue and labor revenue. Conversely, ρ is proportional to i which is part of the invested revenue. We have seen that an optimal rate i exists, for which the consumption is maximal at each instant. Thus, for an economy that has attained maturity, a capitalistic optimum (the term used by Allais) or an optimal value of ρ exists. The optimal value of D is approximately equal to K/ε. Consequently, the value of $\psi = 1 - e^{-\varepsilon D} \simeq 1 - e^{-K}$ is practically constant under optimal management, and the optimal value of D is inversely proportional to the rate of growth.

For an economy at a growth rate of $\varepsilon = 0.06$, eq.(20) yields a value of ρ equal to 1.90 for the optimal values of i and D, i.e., $i = 0.20$ and $D = 14$ years. According to our above statements, for an economy with a growth rate twice as low, i.e., at $\varepsilon = 0.03$, the value of ρ will be 3.80.

This result corresponds rather well to the empirical results obtained in the American economy where generally a mean growth rate of 3% is expected, so that the value of ρ fluctuates around a value of 3.50.

In conclusion, the following statements can be made:

1) The capital - output ratio cannot give a picture of the degree of development of a certain economy, since it is relatively constant in time. According to an empirical study made in the USA (Bibl.13), showing a value of 3.87 in 1890 and of 3.35 in 1956, the figures fluctuated between these two values over a period of 66 years.

2) The capital - output ratio is lower the more rapid the technical progress becomes.

III. EFFICACITY OF INVESTMENTS /28

III.1 Definition of Absolute Efficacity of an Investment

Because of the limitation of capital which, on the national plane, corresponds to the fact that the manufacturers of production equipment have a limited capacity, the entrepreneur can never realize maximum gain. Such objective could be attained only if he had available unlimited sums for investment. The totality of financial restrictions, the uncertainty of future results, are responsible for the fact that the various enterprises cannot enjoy the realized gain to its absolute measure. The important point for such enterprises is to weigh these benefits against the capital to be invested for its realization. The true indicator of the degree of prosperity of a given business thus is the yield of invested capital, i.e., its efficacity.

The efficacity of a given investment is equal to the rate of actualization which equalizes the actualized sum of the net receipts of operation realized during the entire life of the capital and the initial value of the latter.

Reasoning apart from this, i.e., if the balance of net receipts is established every year, the efficacity a of the capital C (invested at the origin of time) and of the duration of D years, procuring a net operating income R_t over the course of the year t, will be defined by the relation

$$C = \sum_{t=1}^{t=D} \frac{R_t}{(1+a)^t} . \qquad (22)$$

In fact, eq.(22) represents the actual value of D annuities with an interest

rate equal to a. These annuities thus are equivalents of a capital C available today. Inversing this problem, i.e., restoring C and the annuities, the /29 quantity a will represent the interest rate at which the sum C would have to be placed for giving the same result as our investment. Thus, it is obvious that a is equal to the annual yield of our capital, i.e., to its efficacity.

Reasoning in continuity, i.e., if the balance is established at any moment and if R(t) represents the net income per unit time at the time t, then the efficacity of the capital will be defined by the value of a, such as the relation

$$C = \int_{t=0}^{t=D} R(t)\, e^{-at}\, dt. \qquad (23)$$

We can reason here in constant efficacities, since we are discussing the case of an exponential model. It should be noted that, within other hypotheses of growth, the efficacity would be a function a(t) derived from a functional relation obtained from the adopted regime of growth.

III.2 Calculation of Absolute Efficacity within the Frame of a Growth Model and the System of Prices Defined in Sections I and II

According to eq.(23), for calculating the efficacity it is sufficient to know the value of the investment and the corresponding operating results.

At the instant θ, a volume of capital $C(\theta)$ given by eq.(17) is invested. Let the value of this capital be equal to $p \cdot C(\theta)$ so that, according to /30 eqs.(16) and (17), we have

$$p.\ C(\theta) = \frac{1}{1-R_c}\ \frac{i}{1-i}\ \frac{\Phi}{\beta}\ e^{\varepsilon\theta}. \qquad (24)$$

This investment yields a production volume defined by eq.(20) having a value of

$$p.\ P_\theta(t) = \frac{1}{1-R_c}\ \frac{1}{1-i}\ \frac{\Phi}{\beta}\ \frac{\varepsilon}{\Psi}\ e^{\varepsilon\theta}. \tag{25}$$

The effective $T(\theta)$, allotted to the investment $C(\theta)$, receives a wage given by eq.(18).

The net income will thus be equal to $p \cdot P_\theta(t) - \bar{W}_\theta(t)$, i.e.,

$$R(t) = \frac{1}{1-R_c}\ \frac{1}{1-i}\ \frac{\Phi}{\beta}\ \frac{\varepsilon}{\Psi}\ e^{\varepsilon\theta} - \frac{\Phi}{\Omega}\ e^{\left(\beta\theta+(\varepsilon-\beta)t\right)}.$$

According to eq.(23), the efficacity a will be defined by the relation

$$\frac{\Phi}{\beta}\ \frac{1}{1-R_c}\ \frac{i}{1-i}\ e^{\varepsilon\theta} = \frac{1}{1-R_c}\ \frac{\Phi}{\beta}\ \frac{1}{1-i}\ \frac{\varepsilon}{\Psi}\ e^{\varepsilon\theta}\int_\theta^{\theta+D} e^{-a(t-\theta)}\,dt - \frac{\Phi}{\Omega}\ e^{\beta\theta}\int_\theta^{\theta+D} e^{(\varepsilon-\beta)t}\ e^{-a(t-\theta)}\,dt. \tag{26}$$

On integrating, we obtain a relation independent of θ which is the date of placing the investment in question and which cannot be resolved by algebraic calculus. Therefore, for a certain number of values of a, we will calculate the value of R_c for which eq.(26) is verified. This will yield the graphic relation between R_c and a.

Expanding eq.(26) in a series, we obtain

$$R_c = 1 - \frac{\Omega}{\beta} - \frac{(a-\varepsilon-\beta)}{1-i}\ \frac{\left(i\frac{\Psi}{a}(1-e^{-aD})\right)}{\left(1-e^{(\varepsilon-\beta)D}\ e^{-aD}\right)}.$$

It is of some interest to define the manner in which a varies, for a given value of C_a, as a function of the lifetime D of the equipment. Table 1 gives the values of C_a for different values of a and D, at $i = 0.20$, $\varepsilon = 0.06$, $\beta = 0.01$. /31

Table 2 gives the values of R_c for different values of a, in an economy under optimal management, i.e., in an economy in which the rate of investment i

and the lifetime of the equipment, at each instant, yield the maximum total product.

TABLE 1

VALUES OF R_c IN PERCENT OF THE REVENUE CONSUMED AS A FUNCTION OF a AND D FOR $\varepsilon = 0.06$

D \ a	0.06	0.10	0.15	0.20	0.25	0.30
7	0.30	3.06	6.36	10.54	15.31	20.34
10	0.11	3.16	8.02	13.88	20.68	28.32
14	0.16	3.48	9.51	17.51	27.18	38.31
20	0.06	3.80	9.91	20.81	34.87	50.68

These results demonstrate that no rate of efficacity, determined in an /32 economy under optimal management, is in existence. The efficacity of invested capitals depends on the price level which, in turn, depends on the share of the capital income in the total consumption. This share results from purely social factors, from the struggle for the attribution share of the product. The efficacity of capital thus is not defined by the conditions of optimum, as stipulated by M.Allais (Bibl.14) who stated that the optimal interest rate is equal to the growth rate of the resources, i.e., in the final analysis to the growth /33 in labor.

According to our model, the efficacity (or the interest rate, in the terminology of M.Allais) is equal to the rate of growth of the resources only in the specific case in which

1) no technical progress takes place,

2) the noninvested revenue is consumed in totality by the wages.

TABLE 2

VALUES OF R_c (IN PERCENT OF CONSUMED REVENUE) AS A FUNCTION OF a, IN AN ECONOMY AT OPTIMAL MANAGEMENT, FOR VARIOUS VALUES OF ϵ

ϵ = 0.06	a	0.06	0.10	0.15	0.20	0.25	0.30	0.40	0.50		
D = 14	R_c	0.16	3.48	9.51	17.51	27.18	38.31	63.81	91.99		
ϵ = 0.084	a	0.084	0.12	0.17	0.22	0.30	0.35	0.40	0.50	0.60	0.70
D = 10	R_c	0.11	1.93	5.51	10.11	19.51	20.56	34.06	51.89	71.26	91.88
ϵ = 0.12	a	0.12	0.15	0.10	0.25	0.30	0.35	0.50	0.60	0.70	0.90
D = 7	R_c	0.30	1.07	3.13	5.77	8.86	12.50	26.15	37.28	49.70	63.04

The results of Table 2 indicate that, in an economy under optimal management, the efficacity is equal to the growth rate of revenue (which, because of the technical progress, is greater than the growth rate of the resources), provided that the wages consume the totality of the available income. If the holders of the capital consume a part of their revenues, the efficacity will be greater than the growth rate. The relation between efficacity and R_c is plotted

in Fig.2, for various values of ε.

By a different approach, we again encounter the results obtained by E.Malinvaud: "The interest rate exceeds the expansion rate if the consumption, correlated with the capital income, exceeds the savings effected on the revenues of the primary factors. If the revenues of the capital are saved in totality and the revenues of the primary factors are consumed in totality, the two rates will be equal" (Bibl.15).

III.3 Calculation of the Relative Efficacity of Investment

If, under the effect of technical progress, equipment of optimum productivity is created, the replacement of obsolete equipment by new equipment is conditioned by the interest that this substitution represents. Such a substitution will permit a saving of future operating cost but, in the immediate present, /34 will require investment expenditures. This constitutes the correlation between an economy based on operating cost and the volume of investment that is responsible for this economy, which yields a measure of the gain of operation.

Similar to the way in which we defined the absolute efficacity of investment by the rate of actualization, which equalizes investment and net income, we can also define the relative efficacity of an investment intended to replace an obsolete piece of equipment by the actualization rate a' which equalizes the cost of this investment and the sum of the operating savings obtained because of the replacement of obsolete equipment by new equipment.

If E_t denotes the net economy during unit time or the inferiority of the obsolete equipment at the time t and if C_r denotes the cost of replacement equipment, then the relative efficiency a' will be defined by the relation

/34a

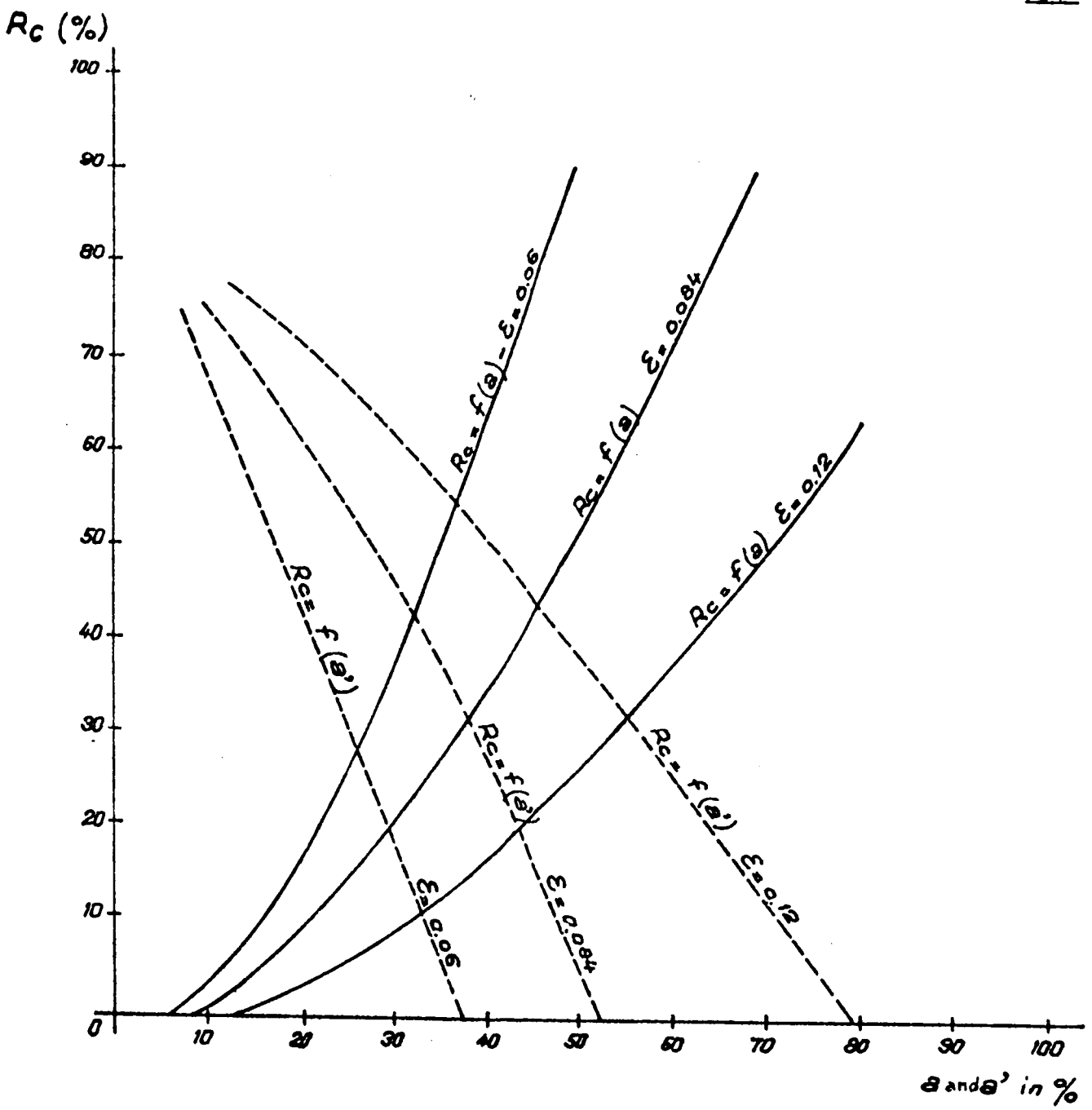


Fig.2 Values of R_c as a Function of
a - Absolute efficacity of investments
a' - Relative efficacity of investment in an economy at optical management

$$C_R = \sum_{t=1}^{t=D} E_t \frac{1}{t(1+a')^t}$$

where D is the life of the replacement equipment.

If one reasons in continuity, the relative efficacity will be defined by

$$C_R = \int_{t=0}^{t=D} E_t \, e^{-a't} dt .$$

In Section II.2, we have demonstrated that the effective

$$T(\theta) = \frac{\phi}{\Omega} e^{\beta\theta}$$

having to do with the investments made at the time θ, yields a production /35
[eq.(20)] of

$$P_\theta(t) = \left(\frac{i\psi}{\varepsilon}\right)^{\frac{\alpha}{1-\alpha}} \frac{\phi}{\Omega} e^{\varepsilon\theta} .$$

The effective per unit product thus will be

$$\frac{T(\theta)}{P_\theta(t)} = \left(\frac{i\psi}{\varepsilon}\right)^{-\frac{\alpha}{1-\alpha}} e^{(\beta-\varepsilon)\theta} .$$

Since the cost of operation is represented in totality by the wages in our industries of total vertical integration, the exploitation cost per unit product, at the time t, for an equipment ready for work at the time θ will then be

$$E_\theta(t) = W_\theta(t) \cdot \frac{T(\theta)}{P_\theta(t)} = \left(\frac{i\psi}{\varepsilon}\right)^{-\frac{\alpha}{1-\alpha}} e^{(\beta-\varepsilon)\theta} e^{(\varepsilon-\beta)t}$$

and, if d is the age of the equipment, $t = \theta + d$ and

$$E(d) = \left(\frac{i\psi}{\varepsilon}\right)^{-\frac{\alpha}{1-\alpha}} e^{(\varepsilon-\beta)d} .$$

The cost of exploitation per unit product is independent of the date of creation

of the investment and depends only on the age of this investment.

If a given equipment, of age D, is replaced by a new equipment, the old equipment, as soon as the new equipment reaches the age d, will have the age D + d if it had not been replaced. The saving realized with respect to the exploitation cost per unit time, due to replacement of a given equipment of age D by a new equipment, will thus be equal to

$$E(D+d) - E(d) = \left(\frac{i\Psi}{\varepsilon}\right)^{-\frac{\alpha}{1-\alpha}} e^{(\varepsilon-\beta)d}\left(e^{(\varepsilon-\beta)D}-1\right), \qquad (27)$$

an expression which yields the inferiority of the old equipment with respect /36 to the new equipment if the latter is of the age d.

If a' denotes the relative efficiency, then the actual value, at the time d = 0 (which is the moment at which the replacement investment is realized), of the sum of the savings realized during the lifetime D of this investment will be

$$E_a = \int_{d=0}^{d=D} \left(E(D-d) - E(d)\right) e^{-a'd}\,\delta d = \qquad (28)$$

$$= \frac{1}{\varepsilon-\beta-a'}\left(\frac{i\theta}{\varepsilon}\right)^{-\frac{\alpha}{1-\alpha}}\left(e^{(\varepsilon-\beta)D}-1\right)\left(1-e^{(\varepsilon-\beta-a')D}\right).$$

On the other hand, eq.(24) yields the value of the investment whose production is given by eq.(20). The cost of investment per unit product will thus become

$$I_1 = \frac{1}{1-R_c}\,\frac{i}{1-i}\,\frac{1}{\beta}\left(\frac{i\Psi}{\varepsilon}\right)^{-\frac{\alpha}{1-\alpha}}. \qquad (29)$$

By equating eqs.(28) and (29), we obtain the relation

$$R_c = 1 - \frac{\frac{i}{1-i}\,\frac{\Omega}{\beta}\,(a+\beta-\varepsilon)}{\left(e^{(\varepsilon-\beta)D}-1\right)\left(1-e^{(\varepsilon-\beta)D}\,e^{-a'D}\right)}. \qquad (30)$$

Table 3 gives the values of R_c as a function of a', for different values

of ϵ, in an economy under optimum management.

TABLE 3 /37

VALUES OF R_c (IN PERCENT OF CONSUMED REVENUE) AS A FUNCTION OF a', IN AN ECONOMY UNDER OPTIMAL MANAGEMENT, FOR DIFFERENT VALUES OF ϵ

ϵ= 0.06 D=14	a'	0.06	0.10	0.15	0.20	0.25	0.30	0.40				
	R_c	76.36	68.01	57.25	44.96	31.42	16.99	-6.70				
ϵ= 0.084 D=10	a'	0.084	0.12	0.17	0.22	0.30	0.35	0.40	0.50	0.60		
	R_c	77.19	72.02	62.22	58.71	45.26	36.02	26.39	6.18	-4.80		
ϵ= 0.12 D= 7	a'	0.12	0.15	0.20	0.25	0.30	0.35	0.50	0.60	0.70	0.74	0.80
	R_c	78.48	76.14	71.94	67.35	62.36	57.04	39.21	26.20	12.64	8.17	-1.34

III.4 Relation between Relative Efficacity and Absolute Efficacity of Investment, in an Economy at Optimal Management

From eqs.(26) and (30), we can derive the correlation between relative and absolute efficacity of investment. The implicit equation, obtained in this manner, cannot be solved either with respect to a or to a'. Thus, we will have to be satisfied with a graphical plotting of a' as a function of a. If, in /38

Fig.2, R_c is plotted as a function of a', the correspondence between a and a' will be obtained for a given value of ε on intersecting the two curves $R_c = f(a)$ and $R_c = f(a')$ by horizontals corresponding to the different values of R_c. The obtained result is plotted in Fig.3.

This diagram represents a result that had been completely unexpected a priori. The relative efficacity of investment varies in inverse proportion to the absolute efficacity. The former decreases when the latter increases. This means that, for a given life of the equipment, the absolute efficacity will be lower the higher the relative efficacity will become or, expressed differently, the price level will be lower the greater the relative efficacity of investment.

In thinking it over, this result is readily explained. We have shown that the reduction in operating expenditures, at the moment of replacing a piece of equipment that has become obsoleted by modern equipment, is a factor of economy, independent of the share of the revenue consumed by the holders of the capital or, in other words, independent of the price level. If this share is low, the equipment cost which results in this fixed reduction of the operating cost will itself be low and its relative efficacity will be high.

This throws a new light on the famous discussion by Terborgh (Bibl.16) on this subject. This author assimilates the relative efficacity to the interest cost and, with respect to the relative efficacities of the order of 40 - 50% /39 and even 100% required by American industrials, speaks of "astronomic interest rates".

Our results show that the relative efficacities of 40 and 100% correspond to absolute efficacities of the order of 10 - 15%, for growth rates of 6 and 12%, respectively. Apparently, until more detailed information can be received, the practice of American industrials seems entirely acceptable.

/38a

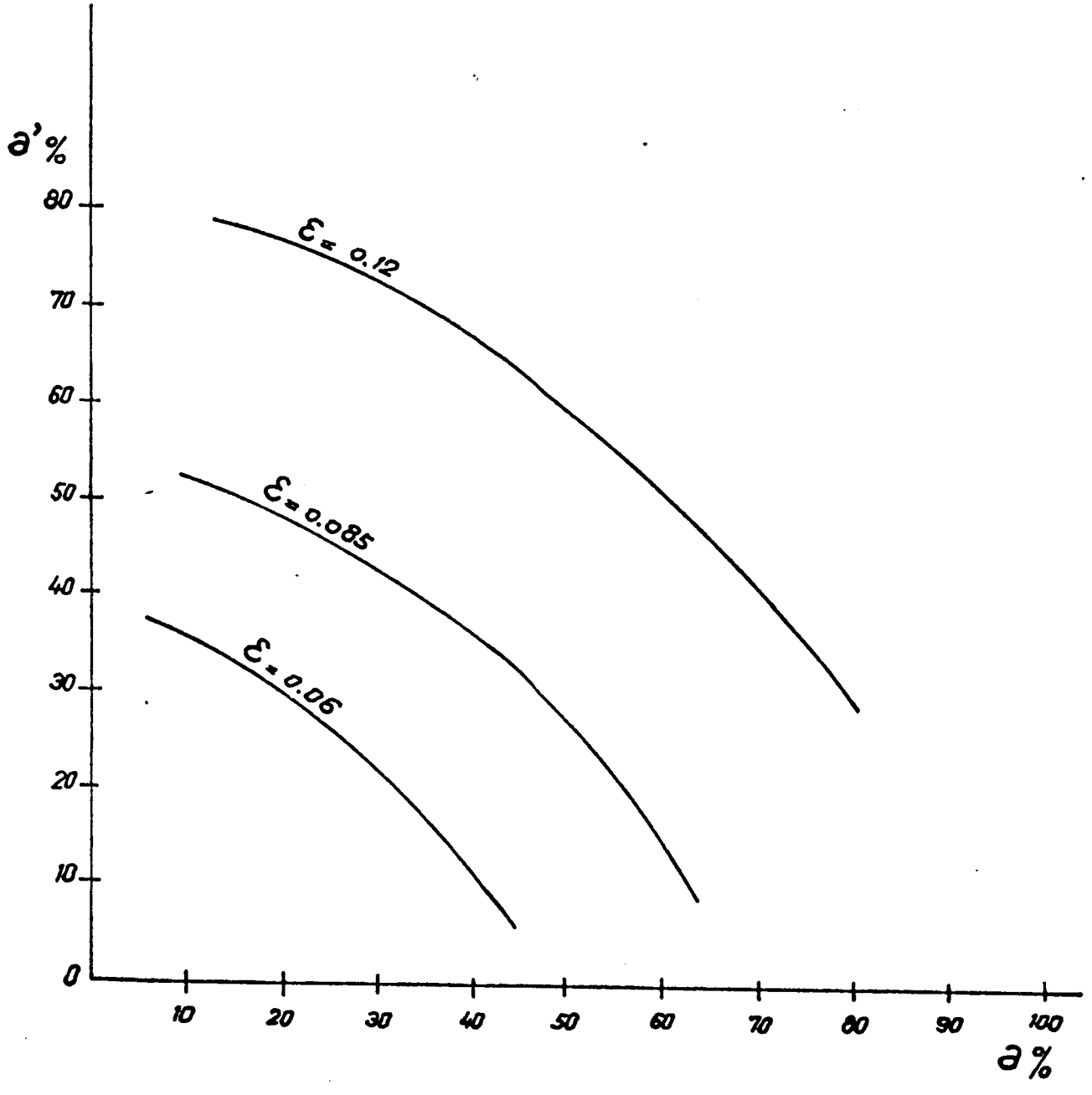


Fig.3 Efficacity a' as a Function of the Absolute Efficacity a, for Different Values of ε in an Economy under Optimal Management

III.5 Recovery Lag

The concept of recovery lag or recession is a commonly used term at present. In the eyes of the industrialist, this concept has the advantage of being "more expressive" than the term of relative or absolute efficacity which, for proper calculation, requires that the relative evolution of prices over the entire life of the investment, in project and in duration, must be known. The production techniques do not progress in a continuous manner, so that this duration obviously cannot be known beforehand.

The recovery lag is equal to the ratio of the annual economy procured by a replacement investment to the cost of this investment. For example, if the recovery lag is equal to two years, this would simply mean that the investigated sums will be "recovered" within two years because of the operating savings realized. It is immediately obvious why this concept is more "expressive". In appearance, the concept reduces the risk of investing. Since, within a relatively short time, at the end of the recovery lag, the business would gratuitously own a modern and new piece of equipment, the operation of replacement would seem attractive and the entrepreneur would proceed with it.

What are the usual recovery lags in an economy under optimal management? /40

Equation (27), per unit product, represents the inferiority of the operating cost of a given investment of age D + d with respect to the investment of age d replacing the former. At the time of replacement, d = 0; this inferiority or the savings realized during the first year following the replacement, will be equal to

$$E(D) - E(0) = \left(\frac{i\psi}{\varepsilon}\right)^{-\frac{\alpha}{1-\alpha}} \left(e^{(\varepsilon-\beta)D} - 1\right). \qquad (31)$$

The cost of investment per unit product is given by eq.(29). According to

its definition, the recovery lag will thus be

$$\Delta = \frac{E(D) - E(0)}{I_1} = \frac{1}{1-R_c} \cdot \frac{i}{1-i} \frac{1}{\beta} \frac{1}{e^{(\varepsilon-\beta)D} - 1} . \qquad (32)$$

Table 4 gives the values of Δ as a function of R_c, in an economy under optimal management, for various values of ε. The Table indicates that these delays are shorter at lower values of R_c, i.e., that the absolute efficacity of investment is low. Equations (36) and (32) also show that a definite correspondence exists between the recovery lag of a replacement investment and its absolute efficacity. We could here repeat point by point the above discussion with respect to the relation between relative and absolute efficacities.

The resultant values also indicate that the values given by American industrialists (recessions of 1 - 4 years) are entirely correct and that the criticism by Terborgh, relative to the low value of these delays, seems unfounded.

III.6 Definition of "Cost of Obsolescence" /41

We demonstrated above that an optimum exists for the life of a piece of equipment and that the optimal lifetime is shorter the more rapid technical progress proceeds. For this lifetime, the total product reaches a maximum at each instant. On the other hand, it was also demonstrated that the growth in total product is proportional to the rate of technical progress. Because of this fact, a rapid technical progress is a highly desirable event.

Since, for a given rate of technical progress, the product passes through a maximum for a given life of the equipment, this lifetime must be shortened to approach the optimal lifetime if the technical progress increases more rapidly.

Under these conditions, the reduction in life of the equipment does not

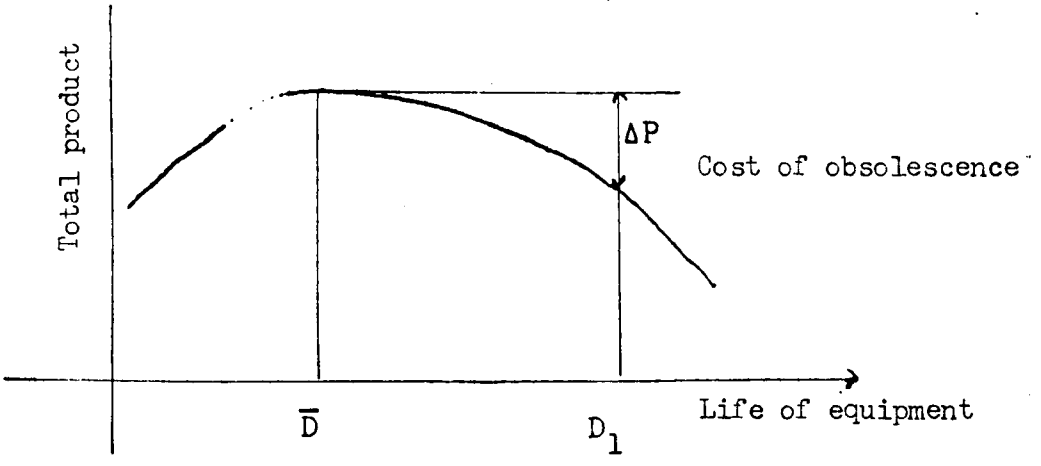
TABLE 4

RECOVERY LAG Δ IN YEARS, AS A FUNCTION OF R_c FOR AN ECONOMY UNDER OPTIMAL MANAGEMENT, FOR DIFFERENT VALUES OF ε

	R_c	1	0.8	0.6	0.4	0.2	0
Δ	ε = 0.06 D = 14	3.22	4.02	5.36	8.05	16.10	∞
	ε = 0.084 D = 10	2.17	2.71	3.61	5.42	10.85	∞
	ε = 0.12 D = 7	1.45	1.82	2.42	3.64	7.28	∞

seem to entail a loss but rather to constitute an advantage since this reduc- /42
tion, as a consequence of technical progress, will lead to a growth in total product.

If the total product, obtained at a given moment, is plotted in a diagram



as a function of the equipment life, this product will pass through a maximum for the value $\bar{D}$. Any piece of equipment of an age below $\bar{D}$ will be kept in operation. Equipment of an age higher than $\bar{D}$, having become obsolete, must be discarded. If such equipment, despite all this, is kept in service beyond the limit $\bar{D}$ (up to an age of D_1 for example) a reduction in total production will result. The loss produced by excessive extension of the service period of any equipment beyond its optimal lifetime is known as the cost of obsolescence. This represents the cost on the entire economic scale, which must be allocated to the retention in service of equipment that has reached its phase of obsolescence.

So far as the various industries, considered individually, are concerned, calculations of the efficacity of investment, as a function of the relative consumption share R_c in the capital income, demonstrate that it is always possible, irrespective of the equipment life, to obtain a given value of R_c. /43 For this, it is sufficient to establish a consequent price level.

The above discussions show that an acceleration of technical progress cannot "ruin the industrialists", even if such acceleration is resented by them as a generator of losses since it necessitates replacement of equipment of increasingly recent age and still in perfect physical production condition. However, this loss in reality merely is a purely fictive "absence of gain". In fact, an extension of equipment life would punish the industrialists themselves, by reducing the total production volume and thus that portion of the revenue which they consume.

FISCAL MEASURES FOR ENCOURAGING SCIENTIFIC RESEARCH /44

F.Panel*

"The work done in preparing the Fourth Plan has focused general attention on the threat to our domestic industry produced by foreign investment. A study of the balance of payments has shown a slight gain of 2.9 million francs for patents in 1960 and a large deficit of 218 million for manufacturing licenses. From this, it can be concluded that, although France has a considerable innovation power which shows in a positive balance of the "patent" account, it is greatly deficient in the sector of exploiting ideas and utilizing the discoveries and inventions. The situation, if nothing is done to remedy it, will lead in 1965 to a deficit of at least 360 million in our balance of 'patents and licenses'. Progressively, France will become a tributary of foreigners on the industrial level; it is mandatory to take cognizance of this situation which threatens to become catastrophic: Our very independence is menaced and only an active and flourishing technical research will permit us to maintain our position in a world in full expansion."

We are quoting from a statement by the Minister of State in Charge of Scientific Research and Atomic and Space Problems, made in an address to the Civil Engineers of France.

Among the various government measures for assisting industry in basic research, fiscal measures are the oldest and thus offer a possibility for in- /45
vestigating their efficacy.

Until 1948, the products received by inventors either through sale or

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* Chief Engineer, General Electric Co.; Group Leader of Industrial Affairs.

assignment, through licensing, exploitation of their patents, trademarks, processes, manufacturing formulas, etc. all were considered gain subject to taxes.

A preliminary bill for a law to be introduced concerns Article 9 of Law No.48-809 of May 13, 1948, exempting from taxes the income received by inventors through sale or assignment of their patents.

Ten years later, the ordinance No.58-882 of September 5, 1958, relative to tax rulings for scientific and technical research projects, stipulated (Article 6) that the assignment of patents (or the licensing of patents) will (subsequently) be recorded at a fixed fee. Thus, long before the authorities and public opinion had become aware of the enormous disproportion existing between the means allocated in France to scientific research and those available to the Great Powers (USA, USSR), the legislators became concerned with promoting basic research, whose nature is non-profit returning in the immediate present and highly ambiguous in long-term yield (with respect to this item, we refer the reader to a recent article by G.R.Pedraglio: "The Concept of Profitableness of Research for the Entrepreneur", published in the "Cahiers d'Études" No.1).

This raises the question whether the wanted effect has ever been reached.

We believe to be justified in stating that stimulation of research by the above-mentioned measures has been extremely slight. The main reasons apparently are the following: /46

Assignment is rarely used as the ordinary mode of transfer of inventions: On the one hand, the inventor prefers almost always to speculate as to the industrial worth of his invention and its commercial success. Instead of a relatively low down payment for his unexploited and frequently unexploitable invention in development work, he prefers - even if it means waiting for years or never

seeing a tangible result - a payment in the form of annual royalties, subject to the commercialization of the object of the invention or of the manufacturing process of the final product. On the other hand, the buying industrialist, although financially tempted to acquire all rights of an unexploited invention for a relatively low price, practically always prefers not to take the risk of outright buying - even at a low price - an invention which might not be successful; he usually is more ready to agree to a staggered mode of payment over a longer period of time, even if the final cost will be much higher, so long as it remains proportional to the commercial success: To buy for a cash outlay of 100,000 francs a nonexploited patent which has rather poor chances of resulting in a rapid and profitable industrial exploitation is much less safe than to pay, over a period of 10 years, a total of 100,000 francs each year for the same invention, starting from the moment at which, after being commercialized, the invention yields sure gains which generally are quite above the royalty itself.

No one ever has attempted to conciliate the fiscal advantage connected with patent assignments, based on the Law of 1948 referring to the assigner or the Ordinance of 1958 referring to the assignee, with the financial advantage connected with payments proportional to the exploitation. However, it should be mentioned with respect to this subject that the Fiscal Administration, based on a doctrine approved at numerous occasions by the State Council, has led to excessive uncertainties in contracts signed under these premises, because of /47 successive and rigorous interpretations. In fact, the Administration has developed a theory according to which any direct or indirect participation of the inventor in the exploitation of his invention, after its assignment, will make him lose the benefit of the above-mentioned tax exemption.

Specifically, the Administration, in implication of the text, has ruled

that an indirect exploitation of patents, posterior to their assignment, is exerted by minority shareholders who hold important functions in the firm of the assignee or inventors hired by the assignee as engineers and receiving a renumeration based on a percentage of the income derived from the assigned patents. It is of course justified that, in this matter, the Administration had the desire to make certain that such assignments will not camouflage ordinary increases in salaries or royalties; however, it must also be emphasized that it is important and common for assignee firms that take the risk of buying unexploited patents, to make certain of the cooperation of the inventor himself for practical development of the assigned invention. Such inventors generally are natural persons foreign to the assignee firm, who usually engage the services of these inventors under consultant contracts. At the moment at which a renumeration of this nature would threaten a loss of benefit of the above law and ordinance for the inventor, the assignment naturally becomes extremely difficult to conclude since usually the inventor refuses a consultant contract so as to retain the tax advantages connected with the patent assignment; in that case, the industrialist will naturally subordinate the acquisition of patents of the inventor to the ensurance of receiving his cooperation in developing the invention potential into an industrially feasible project.

These reasons and numerous others are responsible for the fact that business enterprises (constituting juristic persons) who are interested in exploitation of inventions conceived by the inventors (constituting natural persons), /48 if they have not neglected to take advantage of the above-mentioned fiscal texts, have simultaneously not made extensive use of assignment as a mode of patent acquisition because of the restrictions which - not without valid reason - have been placed by the Law-Making Body and by the Administration on application of

these texts, which has greatly diminished the advantages which they had intended to confer on the interested parties.

A second revision of the law (Law No.62-873 of July 31, 1962) may have been inspired by the above-mentioned facts, since it exempts from taxes all income from the assignment or licensing of inventions, provided that the three following conditions are met:

a) The granting of the license must be exclusive;

b) The license must extend over the life of the patent;

c) The product of the license must be re-applied in the form of immobilization within the enterprise, before expiration of a period of three years counting from the end of the fiscal year (Article 40 of the C.G.I.*, modified by Article 28 of the Law of July 31, 1962 and Note of the D.G.I.*).

The Fiscal Administration, in interpreting the readings in their more restrictive sense, rules that the license granting be economically equivalent in all points to an assignment. This has mainly led to the following:

1) The exclusiveness must be absolute. The assigner must agree not only to grant no licenses to a second contractor but, in addition - according to the Administration - can also not give an exclusive license of a certain application of his invention to a first contractor and another exclusive license of another application of his patent to a second /49 contractor. In addition, he also is forbidden to exploit the invention on his own. This interpretation seems abusive, in view of the absence of not only a legal text but even of any legal precedence. In fact, in French law an "exclusive license" merely means that "a con-

* CGI = General Tax Code; DGI = General Tax Decree.

cession is given to a single person, natural or juristic, for a given territory during a determined period, either for manufacture under exclusion of sale or for sale under exclusion of manufacture or else, if both are combined, for only a portion of the invention, for various portions, or for the totality of the invention". The concept of exclusiveness thus is by no means incompatible with limitations in time and space, with respect to application and mode of exploitation of the invention.

In addition, according to the doctrine which prevails in France at present, the patentee who grants an exclusive license, agreeing by this very fact not to grant another license, retains - unless expressly stipulated otherwise - his personal right of exploitation. Any renunciation of this right does not necessarily presume (Bibl.17, 18, 19)

2) a requirement that the contract of concession contain no resolution susceptible to provoke its expiration before expiration of the licensed patents.

It seems to us that the lawmaker merely had the intention to have the inventor tie himself down, without subterfuge, until expiration of the patent without, however, depriving him of his rights of /50 proceeding against the licensee. We are asking ourselves whether the Administration is not too severe in refusing tax relief to the licenser, by stipulating the conventional conditions: "The contract will cease to be valid, even before expiration of the patents, in cases in which it appears that infringers interfere with the licensee in his exploitation or if the licenser, unable to counteract such

infringement, prefers to cancel the contract".

3) a requirement that the re-application take place in the form of immobilization within the enterprise, before expiration of a period of three years dating from the end of the fiscal year.

It is obvious that both natural and juristic persons rarely are able to satisfy all of these conditions. Despite the fact that there is no doubt that the legislators, 15 years ago, had been concerned mainly with assisting the inventor in his capacity as a natural person, any persistence in this direction would today constitute a deliberate disregard, under the banner of important human factors in the moral order, of the revolution that has taken place in the economic order.

Research, whether basic or applied, with very rare exceptions, because of the enormous expenditure in men and material required, is no longer within the reach of the individual or even of groups of individuals. From day to day, research continues to exceed the facilities of medium-size enterprises and remains accessible only to large firms, finally exceeding the facilities of even large business and becoming accessible only to the State in its various forms, which, in turn, will give way to supranational organizations.

So far as domestic private industry with research laboratory facilities /51 is concerned, which the 1964 legislature must encourage parallel with other concerted government action if the scientific independence of the country is to be preserved in accordance with the terms established by the Minister in Charge of Research, the following points should be recalled:

- Such firms should undertake research with the legitimate hope of arriving at inventions susceptible to feed their production means with improved and novel products, which are thus exempt from royalties to

be paid to foreign firms; they also should refuse to grant licenses that are exclusive per se, except naturally if inventions are in question that per chance have to do with technical fields far removed from the usual area of activity of the business enterprise in question.

- They should voluntarily grant exclusive licenses to foreign countries provided that no local production units are available, but they must be free to subdivide their inventions, application by application, so as to be able to select contract partners that are most competent in either of the areas.
- They should increasingly exchange multilateral licenses, in which case they would be forced to accept or grant nonexclusive licenses.
- They should not tie themselves to a given partner, even if he is well known to them, for a period lasting as long as the life of a patent (15 - 20 years), at a time at which certain techniques become obsolete within five years and at which, because of various fusions and absorptions, the partner of today may, within a few months, change into a competitor or even an adversary.
- They also should not tie themselves down for periods of such length /52 with the only aim of benefiting from tax exemptions, of which one cannot even be sure whether they will remain in force the same length of time.
- In view of the Treaty of Rome which is in force at present, they should avoid being suspected of forming prohibited trusts by granting exclusive licenses; on this point, the domestic directives and the international trends are in direct opposition.
- They should re-apply the collected royalties to reduce the cost price

of immobilization which, in the final analysis, comes down to subjecting such royalties to taxes at a more or less rapid pace, depending on whether the immobilization can be amortized at a lower or higher rate; the firms, except in the case of large enterprises, cannot use such re-application for nondepreciable (land) or participation immobilization (more than 20% of the capital).

In conclusion, the only substantial tax advantage that the licenser of patents can enjoy is that of the elimination of the fee for lease of 1.40%, a cancelation which, because of an Administrative concession, covers also the granting of licenses for manufacturing processes that are not patented.

In an article published in 1962 under the title of "Menace to the French Chemical Industry", Aftalion wrote that fiscal legislation, in its present state, induces the industrialist to prefer, over the constant gamble of research on an industrial scale, the security involved in acquiring a license. In fact, he specifically mentioned that the royalties paid by the French industrialist /53 to the licenser (most often a foreigner) can be deducted from his net income and thus lower the amount of taxes to be paid, whereas the royalties received from a license that the same industrialist grants to the same foreign firm are considered capital gain and thus are subject to a tax of 50%. He concludes, that the State thus debits himself with 50% of the royalties paid by France to foreign countries and collects 50% of the revenue received in this form by France from foreign countries.

Although this example is slightly forced, it nevertheless emphasizes the discrepancy between the desire of independence so frequently expressed by the Government and the contrary effect of some measures in force at present.

While waiting for a thorough reform of French law in matters of industrial

property, it would be highly desirable if - far from suppressing an aid which is judicious in principle and, up to now, quite limited in its effect - the Administration and the lawmakers would manage this properly and rapidly come to the aid of an industry which is at present being accused of neglecting scientific research but which, with its limited potential and its stratified margins of gain, cannot alone stem the rising tide of foreign patents, specifically American, which is the logical outcome of the enormous industrial potential of the USA, the high level of its profits, the large size of private research budgets, and the extensive support granted by the Government which, in itself, is at least equal to the private effort.

PART I

SPECIAL DISPOSITIONS FOR RESEARCH ACTIVITIES BY BUSINESS ENTERPRISES /54

A certain number of measures of a fiscal order have been taken in favor of research activities, specifically those by Ordinance No.58-882 of Sept.25, 1958, Decree No.59-218 of February 2, 1959 and the rectificative Finance Law for 1962, No.62-873 of July 31, 1962. Some of these dispositions are of specific interest for the management of patents and exploitation licenses.

I. DEDUCTION OF OPERATING EXPENSE ALLOCATED TO RESEARCH

The amount of operating expenditure, having to do with scientific or technical research operations, is deductible in the income tax of natural persons or tax on corporations, with respect to short-term gain during the calendar year or fiscal year during which such expenditures were incurred (Article 236 of the General Tax Code).

As operating expenditure only that cost is deductible that truly represents an exploitation expense, which excludes any sums spent on immobilization which can be amortized only over their useful life (see Section II, below).

II. EXCEPTIONAL AMORTIZATION OF EQUIPMENT USED FOR RESEARCH /55

Enterprises that, with respect to scientific or technical research operations, fall into the category defined by the decree of the State Council on investments in buildings, equipment, and tools, are allowed - from the first year of such investment - an exceptional amortization, deductible from taxes, equal to 50% of the cost price of these investments, in which case the remaining value of such investments can be amortized over the service life.

This accelerated depreciation schedule was instituted by the ordinance of September 25, 1958 (Article 39-5-A of the General Tax Code) and revised, with respect to real estate, by Article 23 of the Law of July 31, 1962 (not yet codified to date).

a) Amortization of Buildings Used in Research

Accelerated depreciation can be claimed only by enterprises subject to corporation tax or to income tax of natural persons having to do with industrial and commercial profits, which excludes anyone in agricultural or noncommercial occupations.

The buildings must be allocated to actual research meeting the requirements fixed by the Decree No.58-218 of February 2, 1959 (see Appendix I).

The amortization is equal to 50% of the cost price of the investment made, excluding land (land cannot be amortized). This is added to the first normal annual depreciation allowance but is not cumulative with the exceptional amorti-

zation of 25%, instituted by Article 26 of the Law of July 31, 1962 for /56
certain buildings constructed within the frame of agreed operations.

b) Amortization of Equipment and Tools Used in Research

a) The beneficiary enterprises are the same as those given above (see Section IIa). The conditions to be satisfied by the research operations are the same as those defined by the Decree of February 2, 1959 (Appendix I).

The amortization of 50% is cumulative with the deduction of 10% of the cost price of certain investments that can be applied to the gain taxable under Article 39-7 of the General Tax Code: The materiel used for research laboratory equipment is specifically mentioned in the list established by the Minister of Finance and Economic Affairs (Article 4D of the Appendix IV of the General Tax Code) for application of Article 39-7.

The accelerated depreciation is equal to 50% of the cost price of investment, possibly reduced by:

the amount of 10% deduction mentioned above;

the amount of surtax comprised in the cost price, if this amount has been deducted from the TVA* paid on the sales of the particular enterprise.

This is added to the first annual standard depreciation schedule.

b) This accelerated depreciation schedule, in principle, was abolished again by Article 37 of Law No.59-1472 of December 28, 1959, which substituted for this the system of degressive investment.

However, Article 51 of the same Law enables business enterprises to opt for retention of the previous schedule. Since the deadline for this option /57

* TVA = taxe sur valeur ajouteé (surtax).

has expired on May 15, 1960, the various enterprises will have to adhere to one or the other of the following regimes:

If they had not exerted the option, they will have to follow the schedule of common tax for degressive depreciation, codified in Article 39 A of the General Tax Code.

If they had exerted the option, the schedule of accelerated depreciation of 50%, mentioned above, applies to equipment and tools acquired or manufactured between January 1, 1960 and January 1, 1965 (Article 51 of the Law of December 28, 1959).

III. RECORDING OF AGREEMENTS ON ASSIGNMENT OF PATENTS OR GRANTING OF LICENSES

The assigning of patents and granting of licenses for exploitation of patents must be recorded at a recording fee of 10 francs (Article 670-16 of the General Tax Code).

The recording at a fixed fee of 10 francs of documents covering such operations is practically equivalent to an exemption.

The Administration, in addition, has decided to extend the benefit of recording at a fixed fee to assignments and granting of licenses of industrial property rights (know-how, manufacturing secrets, operating short-cuts, skills, etc.) that are now liable to registration at the National Bureau of Industrial Property. These industrial property rights can thus, in the future, benefit, in the case of assignment or concession, from the same fiscal advantages as those granted to assignment of patents and granting of exploitation licenses.

IV. RE-APPLICATION IN FRANCHISE OF CERTAIN CAPITAL GAINS /58

The deduction of operating expense, described in Section I above, does not

cancel the character of immobilization of patents that can be taken out as a consequence of research performed.

The capital gain which might result from an assignment of such patents is thus permitted to benefit from the re-application in franchise of the tax imposed by Article 40 of the General Tax Code. The sum to be reinvested is equal to the realized capital gain (i.e., to the sales price), increased by the cost price of the assigned patent (i.e., the fraction of the deducted cost of research, as described in Section I above, which had led to the patent).

The benefit of re-application in franchise, codified in Article 40 of the General Tax Code, was extended by Article 28-I of Law No.62-873 of July 31, 1962, to profits derived from granting of exploitation licenses of patents, under the following three conditions:

- that the patent, for the granting enterprise, had the character of an element of the immobilized assets;
- that the license granted was exclusive;
- that this license was to run for the entire life of the patent in question.

V. TAXING OF PROFITS OF INVENTORS

For determining the taxable income of natural persons, the definition of noncommercial and thus taxable gain applies to all products received by the inventor either from the granting of exploitation licenses of patents or from assignment or transfer of trademarks, manufacturing procedures, or manufacturing formulas (Article 92-2 of the General Tax Code). /59

A reduction of 30%, however, is applicable to these receipts so as to allow for the cost incurred by the inventor in developing his invention (Article 93-2

of the General Tax Code).

VI. CONTRIBUTION TO THE COMPANY OF PATENTS OR EXPLOITATION LICENSES

To be eligible for re-application, as defined by Article 40 of the General Tax Code, any acquisition of title remitted as counterpart for the contribution made to a given corporation must ensure to the contributing enterprise ownership of at least 20% of the capital of the corporation that has received the contribution.

However, no percentage of participation is required if the contribution consists entirely of patents or exclusive exploitation licenses and if this contribution has been approved by the Ministry of Finance and Economic Affairs (Article 28-II of Law No.62-873 of July 31, 1962). Such approval or sanction is granted, in consideration of the economic value of each individual operation, on advice by the Management Council of Funds for Economic and Social Development (Appendix II gives the official form of petition for approval).

PART II

DISPOSITIONS ON CONSTITUTION AND OPERATION OF RESEARCH CORPORATIONS OR ORGANIZATIONS

Besides measures of a fiscal order, which have the main object of encouraging research activity in all domestic business enterprises, a certain number of dispositions have the main purpose of facilitating, by a more favorable tax /60 structure, the formation of companies or organizations whose main activity is research.

I. EXEMPTIONS FROM TRANSFER TAX ON CERTAIN GIFTS OR BEQUESTS

The following are exempt from taxes that ordinarily are levied on successions and donations:

- donations and bequests to public establishments or public utilities whose income is exclusively from scientific or non-profit work (Article 1231-2 of the General Tax Code);
- donations and bequests to organizations or public establishments and public utilities whose income is exclusively from scientific, cultural, or artistic work of a non-profit character and which have been approved by the Minister of Finance and Economic Affairs (Article 1231-3 of the General Tax Code).

The field of application of these two dispositions differs. The first is concerned with a procedure of common tax applicable only to public establishments or public utilities whose activity is directed toward research. The second disposition is applicable to "organisms" other than public establishments or public utilities but necessitating previous Government approval. The procedure to be followed to obtain such approval is described in Appendix III. The list of organizations which, until now, have been granted approval is given in Appendix IV.

II. DEDUCTION OF PAYMENTS MADE FOR THE BENEFIT OF RESEARCH COMPANIES OR ORGANIZATIONS /61

A - Enterprises subject to tax on income of natural persons or to tax on corporations are authorized to deduct, from the amount of their taxable gain and within the limit of one per mil of their business volume, any payments made to

public works or non-profit organizations of a philanthropic, educational, scientific, social, or familial character.

For the other taxpayers, the deduction is within the limit of 0.50% of the taxable income (Article 238a of the General Tax Code).

This deduction, outlined in very general terms, concerns practically all organisms of "general interest". Although Article 238a permits payments to research organizations, it had not been specifically conceived for their benefit.

B - Conversely, a similar procedure, but more restrictive in its field of application, exists in favor of research: Without prejudice for the dispositions of Article 238a, all enterprises subject to tax on income of natural persons or to tax on corporations, are authorized to deduct, from their taxable net, within the limit of two per mil of their gross, any payments made to public or private organizations approved for this purpose by the Minister of Finance and Economic Affairs, in virtue of Article 4 of Ordinance No.58-882 of Sept.25, 1958, relative to the fiscal aspects of technical and scientific research (Article 238a-A of the General Tax Code).

Article 238a-A thus permits, with respect to the taxable net, a deduction double that permitted by Article 238a. However, this deduction is granted /62 only to business enterprises (not to all taxpayers) under the condition that the benefiting organism had been previously approved by the Minister of Finance.

Article 238a-A expressly stipulates that the two deductions can be cumulative.

The payments covered by this text are those effected by the enterprise as gratuity, without direct counterpart to its profit, in no matter what form. In fact, the payments, subventions, and renumerations paid by a given enterprise

to a research organization which, in counterpart, would furnish certain prestations in the form, for example, of technical advice, are normally deductible without limitation of its exploitation results. In addition, the maximum deduction of 2 per mil from the gross, allowed by Article 238a-A, can be effected even if the contribution has been made to an organization whose field of research has nothing to do with the activity of the donor enterprise.

Organizations that wish to obtain approval for the obtainment of payments under the above-defined conditions, are referred to Appendix V for the procedure to follow.

III. FIFTY PERCENT AMORTIZATION OF CAPITAL SHARE OF APPROVED RESEARCH ORGANIZATIONS

We mentioned above (Section II, first portion) that business enterprises are entitled to an accelerated depreciation of 50% on investments made in the research sector. The second paragraph of Article 39-5-A of the General Tax /63 Code extends the benefit of this 50% amortization to common stock acquired by private or public corporations and organizations, approved in this respect by the Minister of Finance and Economic Affairs.

The benefit of this amortization is extended to all enterprises subject to tax on income of natural persons or to tax on corporations, even if they themselves entertain no research activity.

The investment must consist of preferred stock of the initial capital of an approved corporation, which excludes the following:

- subscription of bonds;
- acquisition of common stock or capital shares by other shareholders of the corporation.

In the case in which an enterprise does transfer such stock, two ways of

avoiding an application of the already taken accelerated depreciation to the results of the current fiscal year are the following:

- either to proceed, within one year, to a subscription or acquisition of stock certificates of the same nature;
- or to invest in or finance expenditures for research operations in the sense of Decree No.59-218 of February 2, 1959 (Appendix I).

Finally, the capital gain realized by transfer of such stock certificates may benefit from the franchise reinvestment, covered by Article 40 of the General Tax Code, under the conditions of common tax stipulated in that Article.

The procedure to be followed for obtaining the approval, covered by the /64 second paragraph of Article 39-5-A-2, is given in Appendix VI.

A list of corporations or organizations approved since 1958 is given in Appendix VII.

APPENDIX I /65

AMORTIZATION OF IMMOBILIZATIONS ALLOCATED TO TECHNICAL OR SCIENTIFIC RESEARCH
(First Article of Decree No.59-218 of February 2, 1959)

Scientific or technical research operations, in the sense of the dispositions of Article 39-5-A-1 of the General Tax Code, comprise all activities having the character of basic research, applied research, or development operations performed either in the drafting room, computing department, laboratories, pilot plants, experimental stations, or under special circumstances within agricultural or industrial installations, having the following objectives:

- Discovery and development of new production techniques, new manufacturing procedures, new fabrication equipment, perfectioning of existing equipment, and improvement of manufacturing processes already

in use.

- Discovery and development of new manufacturing control processes as well as perfectioning of procedures and control equipment already in use.
- Discovery of new products for novel or known applications, as well as discovery of new applications for already known products.
- Development of new variants of plant or animal species.
- Discovery and utilization of novel raw materials.
- Improvement in factors of production and economic profitableness, /66 specifically in automation and operations analysis as well as improvement in production methods and techniques, conversion and preservation of products, from various viewpoints of quality of yield and productivity.
- Improvement in apparatus and techniques in the medical and veterinary fields.
- Improvement in human working and living conditions.

APPENDIX II /67

PROPORTION OF INCOME FROM PATENTS AND EXCLUSIVE LICENSES
(Questionnaire to be Completed re Applicability of
Article 28 II of Law No.62-873 of July 31, 1962)

1 - Enterprise making the contribution

Denomination or firm's name

Address or headquarters

Juristic form

Activity

Investment capital

2 - Company receiving the contributions

Firm's name

Headquarters

Juristic form

Objective

Investment capital

3 - Nature and value of the contributions

4 - Number and par value of stock certificates to be issued in representation of contributions

5 - Scheduled date of payment of contributions

6 - Substantiation of the petition

Date and Signature

This questionnaire must be completed in 11 copies by the enterprise making the contribution and must be addressed to the General Commissariate of the Equipment and Productivity Plan, 18, Rue Martignac, Paris 7e.

APPENDIX III /68

DONATIONS AND BEQUESTS TO SCIENTIFIC NON-PROFIT PROJECTS
(Questionnaire to be Completed re Applicability of
Article 1231-3 of the General Tax Code)

1 - Designation of organization or establishment

Denomination

Address or headquarters

Juristic form

Objective

Sponsoring agency

2 - Resources of the organization or establishment

Amount and source of income of the past year

Detailed allocation of receipts of the past year.

Enumerate the scientific works to which these receipts refer, indicating for each individual project:

- its exact definition;
- reasons for which it should be considered as having a non-profit character;
- amount of money involved.

This questionnaire, in four copies, must be addressed to the General Delegation for Scientific and Technical Research, 103 Rue de l'Université, Paris 7e.

APPENDIX IV /69

DONATIONS AND BEQUESTS TO NONPROFIT SCIENTIFIC PROJECTS

Below, we give the list of organizations officially approved under Article 1231-3 of the General Tax Code:

Effective Date of Approval	Designation of Organization	Period of Validity of Approval
Oct.9, 1959	Fondation Régionale de l'Ouest de la Ligue Contre le Cancer (Western Regional Foundation of the Anticancer League), Hospices Pontchaillou, Rennes Fondation Curie (Curie Foundation) 26 Rue d'Ulm, Paris 5e Institut de Recherches sur le Cancer de Lille (Cancer Research Institute of Lille), Cité Hospitalière, Lille	Sept.25, 1958 to Dec.31, 1963
Jan.12, 1960	Institut d'Optique Théorique et Appliquée (Institute of Theoretical and Applied Optics), 3 Blvd Pasteur, Paris 15e	Sept.25, 1958 to Dec.31, 1963

Effective Date of Approval	Designation of Organization	Period of Validity of Approval
	Institut Pasteur de Lille (Pasteur Institute of Lille), 20 Blvd Louis XIV, Lille	
	Association Claude Bernard (Claude Bernard Association), 3 Ave Victoria, Paris 4e	
	Centre National de la Recherche Scientifique (National Scientific Research Center), 13 Quai Anatole France, Paris 7e	
	Institut Gustave Roussy (Gustave Roussy Institute), 16a Ave Paul Vaillant Couturier, Villejuif	
	Association pour le Développement de la Recherche Médicale Française (Association for the Development of French Medical Research), 60 Blvd Latour Maubourg, Paris 7e	
	Institut National d'Hygiène (National Hygiene Institute), 3 Rue Léon Bonnet, Paris 16e	
	Institut Pasteur de Paris (Pasteur Institute of Paris), 23 and 28 Rue du Docteur Roux, Paris 15e	
	Institut Pasteur de Lyon (Pasteur Institute of Lyon), 77 Rue Pasteur, Lyon	/70
	Les Fondateurs et Protecteurs de l'Institut Catholique de Paris (Founders and Protectors of the Catholic Institute of Paris), 21 Rue d'Assas, Paris 6e	
	For contributions and bequests given to the following four research laboratories: 1 - Plant Physiology Laboratory 2 - Botany Laboratory 3 - Inorganic Chemistry Laboratory 4 - Organic Chemistry Laboratory	

Effective Date of Approval	Designation of Organization	Period of Validity of Approval
May 2, 1960	Fondation Josée et René de Chambrun (Josée and René Chambrun Foundation), Courpalay, S. & M.	
March 16, 1961	Association Guillaume Budé (Guillaume Budé Association), 95 Blvd Raspail, Paris 7e	

APPENDIX V /71

PAYMENTS TO RESEARCH ORGANIZATIONS
(Questionnaire to be Completed re Applicability of Article 238a-A of the General Tax Code)

1 - Juristic structure of the organization

Designation

Address

Juristic form

If applicable, founding organizations

Name and qualifications of the members of the board of directors

Does the organization have financial autonomy?

Is the organization entitled to receive direct fund transfers?

If negative, give name of organization entitled to receive fund transfers.

Indicate the exact wording under which payments will be made.

2 - General nature of activity of the organization

Does the organization have a profit motive? If yes, what is the allocation of its profit?

Who are the beneficiaries of its activity?

What was the source of its income during the preceding year? (Indicate the percentage, on the one side, of all assessments, subventions, donations and,

on the other side, renumeration for services rendered.)

Indicate nature of activity of the organization. Indicate, in percent of the total expense, the portion of this expense allocated to

- scientific research, /72
- training or teaching,
- other activities (itemize).

If applicable, give reasons why the firm should be classified as a public-interest organization or an organization of collective professional action.

3 - Activities of the organization in the research field

Does the organization conduct research on its own or does it finance research done by other organizations?

If applicable, define the respective portions of in-house research and external research.

If the organization performs research on its own account, give the following data:

- total amount of existing investments,
- personnel employed (research and non-research),
- annual cost of research services,
- nature of research performed,
- respective portions allocated to research and management.

If the organization finances exterior research, give a list of the beneficiary organizations receiving payments, amount of such payments, and nature of the research done. If applicable, state whether this research is done by personnel connected with the financing organization.

Indicate possible auxiliary justifications the organization is able to submit for substantiating its petition for approval.

This questionnaire, in four copies, must be addressed, together with a copy of the statutes, to the General Delegation for Technical and Scientific Research, 103 Rue de l'Université, Paris 7e.

APPENDIX VI

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ACCELERATED FIFTY PERCENT AMORTIZATION OF CAPITAL SHARE OF RESEARCH COMPANIES
(Questionnaire to be Completed re Applicability of Article 39-5-A-2 of the General Tax Code)

1 - General information on the company petitioning for approval

Firm's name

Juristic form

Date of incorporation (or date scheduled for incorporation if the company is in the process of formation)

Complete address (with telephone number)

Type of research done by the company

Address and brief description of existing installations

Personnel employed.

2 - Information on investment capital

A - In the case of a company in formation:

Investment capital scheduled:

Number of shares or stock

Par value

Company capital.

List of probable subscribers; percentage or amount of share of each.

B - Company already in existence

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	Number of Shares or Stock	Par Value	Company Capital
Capital on date of incorporation			
Scheduled capital increase			
Total Emission premium			

Date scheduled for increase in capital.

List of probable subscribers; percentage or amount of share of each.

3 - Information on future projects of the company

Nature of research scheduled or in progress.

Amount of project, by year, with list of projected acquisition of buildings or equipment, and detailed list of cost.

Financing plan, by year.

Date and Signature

This questionnaire, in four copies, must be addressed, with one copy of the statutes (or of the projected statutes) and the last balance sheet (if an already existing company is involved), to the General Delegation for Technical and Scientific Research, 103 Rue de l'Université, Paris 7e.

APPENDIX VII

/75

EXCEPTIONAL FIFTY PERCENT DEPRECIATION OF CAPITAL PARTICIPATIONS OF RESEARCH COMPANIES
(List of Companies Approved under Article 39-5-A-2 of the General Tax Code)

Name of Company	Effective Date of Approval	Life of Approval
1 - COFARS (French Corporation for Application of Scientific Research); see SARST below, No.9	Dec.29, 1958	
2 - Centre Lyonnais d'Applications Atomiques (CLAA) (Center of Atomic Applications, Lyon) Société Coopérative, 93 Ave de Saxe, Lyon	Feb.12, 1959	
3 - Études et Recherches Scientifiques et Industrielles (ERSI) (Scientific and Industrial Investigations and Research) S.A., 13 Rue Pierre Curie, Montrouge	Dec.21, 1959	
4 - Laboratoires d'Électronique et de Physique Appliquées (Laboratory for Applied Physics and Electronics) S.A., 23 Rue du Retrait, Paris 20e	July 27, 1960	
5 - Société d'Études et Réalisations Nucléaires (SODERN) (Corporation for Nuclear Research and Development) S.A., 10 Rue de la Passerelle, Suresnes	July 27, 1960	2 years
6 - Conservatome - S.A.R.L., 18 Rue Seguin, Lyon	April 29, 1960	
7 - Société d'Études pour l'Obtention du Deuterium (SOD) (Research Corporation for Deuterium Production) S.A.R.L., 8 Rue Cognac Jay, Paris 7e	April 29, 1960	
8 - Centre de Recherches de Pont-à-Mousson (Research Center of Pont-à-Mousson) S.A.R.L., Camille Cavallier Ave., Pont-à-Mousson	April 28, 1961	3 years

Name of Company	Effective Date of Approval	Life of Approval
Approval limited to contributions in legal tender during formation of the company		
9 - Société Auxiliaire de la Recherche Scientifique et Technique (SARST) (Subsidiary Company for Technical and Scientific Research) S.A., 14 Rue de Gramont, Paris 2e Successor to COFARS (see No.1) Approval limited to shares issued at the time of capital increase from 1.5 to 3 million francs	Statutory modifications	3 years /76
10 - Centre des Recherches Industrielles sous Contrats (CRIC) (Center for Industrial Research under Contract) S.A., 27 Place Tolozan, Lyon Approval limited to shares issued on formation of the company and two capital increases to 3.5 million francs	May 20, 1961	3 years
11 - Société d'Études de la Propulsion par Réaction (SEPR) (Corporation for Jet Propulsion Research) S.A., 1 Voie des Sables, Villejuif Approval limited to a capital increase of 2,499,741 francs	June 12, 1961	3 years
12 - Études et Recherches Scientifiques et Industrielles de Lorraine (ERSI LOR) (Industrial and Scientific Research and Development of Lorraine) S.A., 5 Terrasse de la Pépinière, Nancy Approval limited to shares issued during formation and capital increase to 0.5 million francs	Aug.4, 1961	3 years
13 - Laboratoire d'Électronique et d'Automatique Dauphinois (LEAD) (Automation and Electronics Laboratory) S.A.R.L., 4 Ave de Beauvert, Grenoble	Oct.17, 1961	3 years

Name of Company	Effective Date of Approval	Life of Approval
Approval limited to a capital increase of 210,000 francs		
14 - Indatom - S.A.R.L., 48 Rue La Boétie, Paris 8e Approval limited to a capital increase of 1.5 million francs	Oct.31, 1961	3 years
15 - Société d'Études et d'Exploitation du Transport Continu par Canalisation Mobile (Corporation for Research and Development of Continuous Transport by Mobile Canalization) S.A., 7 Place d'Iéna, Paris 16e Approval limited to a capital increase of 460,000 francs and an amortization of 25% of new shares subscribed to in legal tender	Dec.1, 1960	3 years
16 - Bertin et Cie - S.A., 28 Rue La Boétie, Paris 8e Approval limited to two capital increases, of a total of one million francs	May 28, 1962	3 years
17 - Société d'Études pour le Développement Économique et Social (SEDES) (Research Company for Social and Economic Development) S.A., 56 Rue de Lille, Paris 7e Approval limited to a capital increase of one million francs and to an amortization of 25% of new shares subscribed to in legal tender	Dec.11, 1962	3 years

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Do business managers make forecasts with respect to evolution in the seven principal directions in which it proceeds? Are they prepared for the problems confronting enterprises in general and entire industries in particular? /78

POTENTIALITIES AND DANGERS OF TECHNOLOGICAL EVOLUTION

J.R.Bright

The probably most striking characteristic in the world in which we live is the increasing capacity of man to become master of his physical environment. Although the technological evolution, which is the cause of this progress, cannot differ with respect to its conception from what it has been all through history, the repercussions seem more pronounced because of its rate of advancement, rapid frequency of its introduction, extent of the resources responsible for such evolution, the rate of its diffusion, and its interdependence with political, economic, and military events. In addition, these technical changes frequently are more extensive if they occur in combinations rather than as individual progress, of which guided missiles and the nuclear bomb are sad examples. I am convinced that technological evolution is the factor exerting the greatest influence on the various enterprises. For the general public, automation might be the predominating factor but this is only one of the many trends followed by technological evolution. /79

1. Enormity of the Repercussions

Technical evolution is not only impressive because of its variety but also because of the "chain reaction" resulting from its effects on industry and on society. Let us examine a few typical examples:

Guided missiles have led to a reduction of the effectives of aircraft

construction firms, reducing their personnel to less than one third of what it had been six or eight years previously. Missiles were the cause for the creation of new enterprises, counting in the thousands, for supplying highly perfected technical specialties. This resulted in shift in employment, increase in knowledge required for manufacture, changes in training required of development engineers, establishment of different industrial installations, different procedures, and new services. This created demands for new power sources, new fuels, new materials, control systems, and testing equipment. The result was increased activity in basic and applied research which, in itself, is more extensive than most of the traditional industries combined. At the same time, guided missiles indirectly cause a reduction in numerous activities required for maintaining the flight characteristics, inventory, and conventional operating mode of military aircraft.

Television which, in less than 10 years, has become a standard piece of furniture in the home has practically disrupted the conventional form of the motion-picture industry, has made serious inroads into the domain of publications and popular magazines, and has become a powerful medium of advertising /80 and a formidable competitor for publicity budgets. As an educational instrument, we have barely scratched the surface of television.

The electronic computer, constituting the most powerful concept of mechanization since the creation of electric energy, has led to the development of an entirely new industry, with myriads of special elements and numerous suppliers of hardware for its manufacture, since its very first commercial installation in 1952. The expansion in the computer field goes far beyond what even the most enthusiastic proponents of this device could have predicted 10 years ago, and its application has such far-reaching and such profound effects that we can

barely guess at even a few of its consequences.

The space program, comprising our national effort to extend the physical domain of man in the universe, can hardly be comprehended in terms of money but can best be judged as a function of its share in the national income. Such investments are made for goals which are difficult to justify in conventional terms. This effort also has led to the creation of novel research domains, new requirements for research, new tools, materials, control systems, power sources, and the necessity of extending the limits of the physical endurance of human subjects. New organizations became necessary, resulting in new collectives such as Cape Kennedy and the Manned Space Flight Center at Houston. It is clear at present that new forms of international collaboration will be necessary for testing, training, and exploitation in this field.

2. Necessity for "Stock Taking" /81

There is no doubt that our epoch of dynamic commercial evolution is founded on technological progress. In this evolutionary environment, products, materials, procedures, and manufacturing installations become obsolete within a few years and, in some cases, within even a few months. At the same time, new discoveries of science and new success in technology offer possibilities of equal extent. The demand for new technological progress seems without limit. Thousands of enterprises will be created and will disappear again, depending on the capability of their management to effectively apply themselves to the problem at hand. How can management master this environment and confront it within reason? These new demands do not always present themselves obediently at the door of obsolescent enterprises, and potentially revolutionary innovations do not announce their birth at the sound of trumpets.

No sure formula exists for achieving success and security in this technological fermentation; however, managers of all types - industrial, military, political, and social - must become much more flexible in the face of technological evolution. I am convinced that the imperative principle for a businessman is a sharp awareness of and sense for technological evolution, combined with receptivity to such progress constituting an irresistible force which he can subjugate and to which he must subject himself. In numerous enterprises, this would be the most important force by far. Formal predictions, so far as technology is concerned, are extremely difficult (and even naive); however, it remains true that technological progress must be forecast in some manner or other. Progress is an evolutional phenomenon which possesses origin, cause, direction, rate of advance, and total successive effects. If it were possible to follow its progression, its effect on other forces composing the business atmosphere, and the resultant reactions on this atmosphere, then it would be much easier /82 to forecast the probable economic and commercial consequences and to take the necessary measures.

3. The Seven Trends

In the basic wish to obtain clarification, I have identified seven important technological trends. All of these have been compiled in a Table, giving a list of the principal domains of progress, means of typical progress, and results of significant importance. Within the text, I will give a summary description of certain general commercial consequences of these trends. In the conclusion, forecasts will be given on the vast repercussions of technological evolution in industry.

a) Transport

Appendix I shows some of the basic elements of the history of transportation. We will start with the mastering of distance by man. The fundamental result of progress made during the last 10 years in this respect is that the geographic characteristics of the globe have lost a good portion of their traditional significance. Geography (or, simply expressed, distance) no longer constitutes such a great barrier, drawback, or factor in war or trade. At present, it is the control by man that establishes limits in this respect, while geographic features and the cost or time of transportation no longer are significant. A basic consequence is that competition and possibilities of commercialization develop among regions that earlier had been separated by delay in transportation or economic factors. The search for optimum utilization of the resources of a given region promotes geographic specialization. /83

An important result of the increase in frequency of travel is the rapid and generally widespread exchange of cultural, economic, political, and technological ideas. It becomes easier to transmit ideas from one point to another and becomes harder to keep concepts, ideas, and procedures in secret and isolated from the rest of the world.

With the availability of various technological devices for transportation between given points, a logical consequence is an increasingly severe competition between transportation systems and services. Similar to the way in which railroads have superseded canals and themselves were replaced by truck, automobile, and aircraft transport, so do the modern means of oleoducts (hydraulic tubes), hydrofoils, rolling carpets, and specialized vehicles threaten to replace existing means of transport.

With respect to operation in a novel environment, the efforts made for

mastering space travel and submarine exploration require such complex equipment and create such a sustained demand for novel technical developments that a large number of businesses will have to be based exclusively on satisfaction of technological progress requirements, independently of the satisfaction of production volume requirements. However, this technical progress will finally lead to the possibility of commercial business. For example, a new industry which will become of extreme importance is that for manufacturing life support systems, permitting man to survive in environments to which he is not adapted. In addition, to the extent that the ocean depths are conquered for military purposes, this technological capability will eventually also be applied to pacifistic ends. In the future, the resources of the oceans and of submerged land will no doubt produce a basis for new commercial activities. /84

b) Energy Production

As indicated in Appendix II, the technological progress in the field of energy production has numerous ramifications and is still in such a state of fermentation that dominant trends cannot yet be discerned. Never before have there been so many alternatives as available to the human race at present, with respect to fuel sources, electric power production processes, forms of energy transport, modes of application, and measures of control. At present, the commercial consequences of the pursuit of progress can be outlined only roughly.

Merely as a suggestion as to the repercussions of such developments, let us examine an example of the second category mentioned in the Appendix, namely, the transport of energy:

A significant development is the increase in the sharing of energy and electric power combines, made possible by superhigh voltage transmission lines

(SHV). The transmission of electric power of 230,000 volts and more, instead of 115,000 and 138,000 volts as is conventional today, will permit the transport of electric power at a much greater efficiency and over much larger distances. The result will be electric power centers of greater size (comprising both atomic power stations and conventional power sources). Since the capacity increases with the square of the voltage, the higher cost price of such construction will be more than amortized.

For example, a transmission line of 345,000 volts will carry a power more than nine times that transported by a 115,000-volt line, but will cost only /85 four or five times more to construct. The Power Pool of California (grouping four Public Service Companies) has a project for a SHV system, based on the transmission of 500,000 volts or more and making use of hydroelectric power stations located in Oregon, more than 650 miles away. General Electric and Westinghouse are working on developing systems of 750,000 v and 1,000,000 v. The estimates seem to indicate that, from now until 1970, about eight billion dollars will be spent for such SHV lines. This means that the present power suppliers and the power transmission systems will face considerable competition because of such superhigh voltage transmission lines.

The more extensively technical progress in the power domain is studied, the greater appear the possibilities for conventional businesses (or the more violent appear the immediate upheavals). On April 10, 1963, for example, the newspapers announced that the Navy requested authorization to operate all its combat vessels of more than 8000 tons on nuclear energy. Not much imagination is needed to understand that this would involve considerable changes for the manufacturers of traditional naval systems with conventional electric power and control units, as well as for suppliers of fuel to the Navy, manufacturers of

materiel, refueling tankers, and for many others.

Competition is developing between conventional power sources, production methods, power transmission methods, and fuel transport systems. No doubt, there will be an intense technological competition between the principal /86 systems of production and distribution of power. The demand for power presumably will continue to increase, and the general technical progress makes it possible to predict a decrease in cost price per unit power. It is obvious that technological and economic shrewd and imaginative strategies must be applied, specifically by manufacturers of power equipment and by service suppliers who are, at present, the only businesses able to service a single power system.

c) Organic and Inorganic Life

As indicated in Appendix III, technical progress of great significance has been made in the control of organic growth, preservation of organic products, and reduction in the deterioration of physical products. A general consequence of the control of organic growth is the increase in the economic value per unit production. This has a tendency to result in a reduction in cost price per unit production. However, such progress requires two conditions:

a) mechanization;

b) scientific agricultural production, based on proper soil and foodstuff management, as well as protective treatment of harvests and animals.

Because of the fact that such developments require greater capital investment and superior technical capabilities, there is a tendency toward large-scale production. It appears that the small producer will have less and less possibilities to benefit from or to allow himself such technical and economic contributions.

Far-reaching consequences for both manufacturing enterprises and service enterprises are created by the efforts made to reduce deterioration (the third domain of progress in order of importance, as listed in Appendix III). In /87 general, it would appear that maintenance required because of deterioration will be reduced in magnitude. This is largely counterbalanced or even canceled by the increasing complexity of control systems and by the improvement in services expected from durable goods. However, it seems that - despite the increasing complexity of durable goods - progress is being made in their operational reliability. To the extent that these tendencies are dominant, it could be maintained that the replacement of goods because of wear is diminishing. For many industrialists, the policy of equipment replacement will depend more on the changes in characteristics and style (technique or mode) than on the wear of the materiel itself.

This necessarily means that, to the degree to which the operational reliability increases and the distribution systems improve, an evolution will be produced in maintenance, supply of parts, and processes of repair. Because of the extremely rapid rate of increase in technical complexity with respect to large numbers of products, the requirements of maintenance may become predominant at certain times, and may even furnish the basis for large-scale commercial activity.

d) Characteristics of Materials

"Molecular engineering" is the apt term given by Dr. Lee Dubridge to the technological efforts made in modifying the material characteristics. The resultant effect is extensively felt in industry (see Appendix IV). Very little security exists for numerous raw materials in their traditional markets. Sup-

pliers and converters of raw materials must expect that the competition between the various materials will become increasingly severe. Simultaneously, new markets will open for conventional materials, in step with the technological changes in the material characteristics for adaptation to new objects or in /88 step with the development of ingenious combinations with other materials for satisfying special requirements. This intense competition in the field of materials seems to indicate that the value of certain goods, based on raw materials, will undergo substantial alterations, unless suppliers and converters reduce their prices or propose technological progress in the physical characteristics.

However, the exploitation and protection of material markets requires Research and Development which, in turn, requires time and money. Despite the fact that many enterprises are able to provide the necessary funds, they cannot always buy the time required for R & D. Management, therefore, must institute Research and Development activities in sufficient time to have them become effective from the commercial viewpoint. It is not sufficient merely to end up by creating a novel material. Such new materials usually require also new procedures and new production equipment. In most of the cases, this means an equivalent research effort in the manufacturing field and large investments in new basic equipment. Taking new equipment into operation proceeds at the expense of the old equipment. Thus, progress in materials offers both potentialities and risks for certain manufacturers of equipment goods.

Technical obsolescence of existing materials, production systems, and manufacturing techniques also results in changes in the sale of materials. Sales are made much more on the basis of technical quality of the materials than merely of delivery time or price. An increase in products specialization is /89

unavoidable, which automatically leads to a multiplication of the range of products by equipment suppliers. The sales effort must become more technical, which will occur automatically since sellers of equipment must be able to translate the needs of their customers into terms of applicability and suitability of their product. The salesman must understand the economic and technical conditions of the manufacturing processes of the customer as well as the application of the product to be sold, in comparison with materials marketed by competitors.

The progress in materials also offers enormous potentialities for further improvement of the products. It is inconceivable that the utilization of new materials will not cause industrial and consumer goods to become more substantial, lighter in weight, less costly, more attractive, and more durable. I am convinced that, in many instances, the end user of the materials will be competitive in the market, exclusively because of some properties that the use of novel materials has imparted to his product.

e) Sensory Capabilities

The past 15 years have brought considerable extension of the sensory capabilities of man (Appendix V). We are able to see, hear, or otherwise identify conditions far beyond the field of vision or range of hearing of humans and can thus function under conditions that previously had excluded or limited the performance. In addition, a considerable increase in the range of action over long distances has been achieved, namely, remote control. One can readily consider this as an extension of the power of accession of man. Thus, the movement of /90 mass and the flow of energy are controlled with greater accuracy over continuously increasing distances. This leads to two consequences: a reduction in

manual labor and an increase in the speed of reaction to conditions existing at a distant point.

New industries were created so as to further extend these capacities of sensation and control. Instrumentation and control systems are among the most important activities of this expansion. Rapid technological advance has been made in miniaturization of instruments but also in rate of obsolescence of products. The progress made in extending the memory of man (photography, polaroid film, videotape, xerography, and other processes) is also at the root of significant business activities.

f) Physical Mechanization

Appendices VI and VII show the two types of mechanization obtained. Numerous discussions exist on both. We will only summarily comment on their consequences.

Let us first discuss the mechanization of physical activities. In general, there is a considerable reduction in the proportion of manual labor required for the production of each unit. On the other hand, designers of automation equipment have increased manual labor involved in production of the equipment, despite the fact that this probably is not in proportion with the labor-saving aspect of the output of their equipment. It is common knowledge that the jobs of qualified operators, either eliminated or simplified by highly automatic equipment, are numerous; nevertheless, mechanization also eliminates many jobs that do not require special qualifications. To the extent that the capacity /91 of equipment has increased or that such equipment is novel and unique, a more important and more qualified effective may be necessary for its maintenance. Thus, it is generally impossible to predict the true effect produced on the

labor force, unless to state that - in certain cases - this effect is extensive and in others negligible.

An important result is the fact that products of extreme complexity, which are constructed in only a single specimen such as spacecraft and certain computers, require an extraordinary amount of qualified manual labor for assembly, testing, and control operations. This raises the composition and the technical level of the work effective to a significant proportion.

Numerous exceptions to these concepts could be cited, and the interested reader is referred to other more critical studies (Bibl.20, 21); see also the Chapters on this subject in my book "Automation and Management" (Bibl.22). In addition, the industrial survey of the Department of Labor also contains results of numerous investigations. The main concept here is that of an accrued proportion of the share of machines in most of such activities.

g) Intellectual Mechanization /92

Let us now consider the mechanization of intellectual processes. At present, it is difficult to estimate all possible repercussions of the electronic computer. Such as it exists today, the computer is being applied to the most surprising activities. A perusal of the pages of the Wall Street Journal and Business Week, over the course of the past year, brings home the fact that the computer handles widely divergent problems such as the law on patents, the collection of taxes, the programming of Broadway plays, the realization of electric equipment circuits, the direction of study projects, the management of department store inventories, the analysis of petroleum refining processes, the law on health, the handling of data, and numerous other tasks. In each of the cases, one of the most important consequences is the reduction in time required

for accomplishing a given activity, while the second important feature is the improvement in accuracy and detail of the work done.

The mechanization of intellectual processes, once the program has been laid out, greatly reduces the delay usually involved in organizing a given job and improves the accuracy in proportions much superior to human capabilities. One question that is still not settled is that of its effect on the qualification required of the operating personnel. The qualifications demanded in numerous areas of intellectual work have been greatly reduced. However, the qualification, required for analyzing and programming a given problem, before feeding it to the computer, has definitely been raised. It can be predicted at present that the mathematical skill required at the level of management and operators will increase further.

Programming and retroactive control of computer operation greatly shorten the time required for organizing, raise the accuracy of the results, and lead /93 to a substantial increase in use of the equipment (because of the reduction in delay of arranging and because of the fact that the machine operates without human intervention). In many cases, this modifies the aspect of cost price, since it is no longer necessary to schedule auxiliary expenditures for obtaining a greater precision, inherent to the system.

Here again, we see the creation of numerous and important new industries, based on the design and construction of computer hardware and accessories. The conception and adaptation of machines for program control extends clearly into the industry of toolmaking and related fields.

4. Conclusions

When considering the overall aspect of all these trends and tendencies,

certain topics repeat and cumulate. In fact, 11 different consequences can be forecast for the immediate future.

1) "Competition will increase from geographically distant regions." The businessman will have to watch the conjunction of three different developments:

- Shortening of transport time for products, thus permitting various competitors to invade his markets, with possibly greater accommodation and flexibility toward the requirements of the customer.
- Greater volume of shipments which will require new systems of packing and maintenance and, in certain cases, new specialized techniques for the transport of a single product (for example, oleoducts).
- A better interpretation of the procedure of distribution, integration of maintenance systems, packing, and transport in addition to the technological progress in such systems, which will lead to a reduction in cost price such that the merchandise could travel many more miles for the same amount of dollars. Distance will decrease in importance as a barrier to competition. /94

2) "Competition will increase and make its appearance from unexpected and unorthodox quarters." A certain kind of competition will be created in the field of products that normally are noncompetitive because of certain characteristics of realization or cost price. For example:

Paper has never been a competitor in the field of clothing, except for handkerchiefs. However, to the extent that chemists are able to impart new properties to paper - properties that are equivalent to those of textiles - and that engineers reduce the cost price, it is quite likely that paper will become a formidable competitor of textiles for certain types of clothing. This is exclusively a question of properties, price, and - to a certain extent - of

imagination in commercialization, in addition to the obvious delay in becoming socially acceptable.

Synthetic materials will compete with traditional materials. Thus, the leather industry - at the present moment - just about starts to be affected by the competition of the chemical industry (for example, Corfam made by Dupont).

A much more insidious type of competition, much more powerful and disturbing, is created by the technological progress which procures for the customer the desired product and circumvents or replaces existing products and systems. A typical recent example is television which originally was not meant to be an improvement in the technique of production or presentation of motion pictures and which, nevertheless, has completely upset the conventional trade of the motion-picture industry by offering the customer an entirely different mode of visual entertainment. /95

When looking into the future, quite similar developments can be anticipated:

An event to be expected soon will be the replacement of certain coal transport by railroad, due to electric power transmission at superhigh voltage, which makes it much more economical to transport electricity itself than to ship the coal from the mines.

I am certain that we are only a step (and not even a technological step but only a price step) away from competition between communications and business travel with respect to dollar expenditure. Why do businessmen travel at all? To engage in verbal discussions? To thresh out contracts? To have a personal meeting? To check on each others' characteristics of products or services? To exchange documents? To sign papers? All these points can just as easily be attained by integrated communications systems such as closed television circuits, duplicating machines, teletypes, and similar equipment. How much time,

for example, will it take before American Airlines will experience competition by "American Communications Inc."?

It will require extremely skillful and well-versed managers to predict and counteract this type of competition. The situation certainly implies a decrease in gain for conventional suppliers.

3) "The possibilities of commercialization will increase further." A given society will no longer be limited, as had been the case previously, to certain regions and to certain industries. Rather, to base oneself on the potential of commercialization requires a) an aggressive and active attitude /96 toward technological evolution and b) the willingness to risk money and reputation in a technological innovation.

4) "The competitive lifetime of numerous products will diminish rapidly, because of technological obsolescence" (which differs completely from physical deterioration or antiquated design). It is a striking fact that, the more a product presents special characteristics and complexities, the greater will be the possibilities it offers for perfectioning or improving the product. A very simple example in this respect is the 35-mm color slide projector which is familiar to many. Let us briefly study this aspect:

It is logical that the manufacturers (and some of these are among the best in the world) were interested in manufacturing projectors with all desirable characteristics including preloaded cartridges, automatic speed selectors, remote control, remote setting, and other advantages. Nevertheless, I personally had the sad experience in my own lecture hall to handle about 15 different projectors, none of which satisfied me completely from the viewpoint of remote control for teaching purposes.

Despite all improvements, the technicians or manufacturers have been unable

so far to produce a projector with the following properties: a) adaptable to any type of slide mount; b) neither wrinkling nor distorting paper-mounted slides; c) never jamming; d) not requiring preliminary mounting into special frames; e) offering a remote-control device of sufficient simplicity for having the demonstrator learn the technique without spending hours on it; f) offering a simple and direct method for inserting a given slide which had slipped out of sequence; g) offering a high-quality lens system; h) operating with a minimum /97 of noise; i) liberating an amount of heat that will not damage the slides nor their plastic mounts.

Some of the presently available projectors have some of the above advantages but none have all of them. If anyone wants to look for greater possibilities of commercialization, let him offer something that a) operates properly and b) presents characteristics demanded by the customer.

5) "Not only the delivery time but also the cost price requires the creation of novel products, which would be supplementary to the effort in the R & D field." The more a given product is affected by technological obstacles and the more complex or sophisticated it is, the greater will be the amount of work required in Research and Development. One factor of considerable significance is the fact that a given large enterprise might well have available sufficient funds for realization of an urgent program of making up for the work spent on R & D, but is unable to recover all of the lost time or to take out a sufficient number of patents. The "evening chores" necessary in Research and Development (R & D) must be done every evening; it requires quite some time to acquire the necessary know-how and use facility.

6) "By gains in the domain of productivity, superior conception, technological competition, and economic factors ruling the large enterprise (including

the economy of distribution), the cost price of numerous materials, products, and services can readily be reduced." Typical examples are the cost price of electric power, automobiles, air transport, and household appliances, if the /98 value of the dollar and the quality or degree of service obtained are taken into consideration. The cost price may decrease to the extent as novel procedures of commercial tariffs are instituted. For example, the cost of local communications and special telephone night rates extend the buying power of the dollar. Similar tariff policies may greatly affect the demand itself, the moment at which such demand is created, and the cost price as well as the distribution processes. In the final analysis, it is the expert in tariff and the commercialization strategist who decide the success or failure of technical innovation.

However, for numerous products, the reduction of certain elements of the cost price will be counterbalanced by the requirements of increasing complexity and capability of realization.

7) "Numerous novel commercial possibilities will result from the availability of technological progress in materials, services, and testing equipment, together with the corresponding production processes." Since any major advance greatly increases the demand for new things, it must be expected that many possibilities are created and that these will appear so rapidly that a given firm might be totally unable to take care of all of them. A proper analysis of the demand for goods, resulting from the principal technological developments, would be of considerable assistance to small enterprises so as to enable them to compete. It is highly desirable to have all enterprises show more discernment, resolution, and initiative. A typical example is the following:

The space program has been the cause of some of the most extensive mainte-

nance work in all of history (transportation and manipulation of missile elements during their manufacture, and launching operations of spacecraft). These operations become increasingly colossal as the size of the rockets increases. /99 For example, the Saturn project requires the displacement of a piece of equipment, weighing 12,000 tons and having a height about that of the Washington Monument, over a distance of 2 miles from the assembly point to the launch pad, and all this at a rate of one per week!

Nevertheless, does the industry manufacturing the maintenance equipment for this materiel make concentrated and constant efforts to solve these new maintenance problems? With a few notable exceptions, most of the firms have given over this new field of activity to other enterprises and waste their efforts in struggling in their conventional market, despite the fact that this market has reached a high point of saturation and is subject to intense price competition. Why is this so? We could suggest a lack of imagination, lack of awareness, lack of interest in government markets, lack of capital, reluctance to attack unfamiliar work, and many other causes.

I have no intention to have this commentary boil down to a criticism of the manufacturers of maintenance equipment, but merely to give a typical example of the manner in which numerous industrialists respond to relatively novel commercial fields.

8) "Firms unable to confront the technological shift, to predict such changes, or to develop in the required direction will of necessity be overrun by superior technology." For example, the Diesel locomotive put an end to the steam locomotive not much more than 12 years ago. Similarly, to the extent that the final products have shifted, numerous subcontractors that procure materials, parts, equipment, or services, will disappear. This leads to an interesting /100

suggestion: A major portion of the success of individual firms depends largely on the capability of the customer to meet technological competition. Will it finally become necessary to study the technological future of our customers as much as our own?

9) "There exists the probability, just as upsetting for the employee as for the company, that job security is not necessarily a consequence of a sound traditional management, of a good market, of proper financing, of good equipment, and of competitive cost price." In the entire history, no automation equipment has ever eliminated jobs as rapidly as the transition from bombers to guided missiles. It is true that certain new jobs were created. However, these did not concern the same employees and were not available at the same localities.

The slogan of labor unions: "look at the accounts!" is of no true significance at present. A much more appropriate defiance labor unions should hurl at management would be "look at the program!". Does management actually take the measures necessary for technologically staying "alive"?

10) "The display of power of the American Government becomes ever more distinct." Despite the fact that a large number of managers loudly complain about interference or participation of Government in business, the fact remains that governmental decisions are the determining factors of prime importance in most technological progress. It is Government that sponsors research, development, and practical application. Government frequently undertakes the financial risk of the innovation and actually selects the direction of evolution and the technological solution. We must all realize that it was Government that took the responsibility for development of digital computers, purchase of the first large electronic computers, inauguration of jet engines, mass production of /101 penicillin, development of guided missiles, promotion of atomic energy, initia-

tion of space programs, and numerous other developments.

Let us mention also that the projects themselves become so complex, so costly, and so far-reaching that we would even need several governments for making the forecasts and procuring the financial means, such as is the case for the Mach-2 supersonic transport. The corollary should be clear for management: Businessmen must keep abreast of technological decisions made by government agencies and must be willing to cooperate.

11) "Commercial decisions will carry a much greater portion of risk (and more failures) in this new-type world." In some manner or other, high-level management should encourage the acceptance of a certain risk and must itself be prepared to accept the failures that unavoidably accompany such decisions. Here lies one of the greatest weaknesses of most enterprises. The conventional system of basing the remuneration of a given director uniquely on the gains of the preceding year "encourages no one to pursue a project that will not be profitable within a period of five years". The traditional system of remuneration as well as the traditional organization are in need of basic reform, with the purpose of encouraging a sane appreciation of the technological possibilities and of establishing reasonable cooperation.

5. Epilogue

It appears that the participation in technological innovation is becoming increasingly significant and more frequent in the entire society and in commercial management in particular. Despite the potential presented by numerous technological advances, I personally feel that management would be entirely /102 justified to say "No" more often than "Yes". However, it is necessary to gather more data on the overall process. One must become familiar with the manner of

evaluating technological progress, making use of it, decelerating it, and defending our business enterprises against technological evolution in the case of necessity. No one will shed tears over a business which folds up because of the lack of technological discernment, except for those whose life, employment, and fate is dependent on the erroneous conjectures of job security made by such firms. On the other hand, technological innovation offers one of the optimum perspectives for growth of a given company, the security of employment, and the success of its economic expansion.

APPENDIX I /103

RISE IN TRANSPORTATION POTENTIAL

Field of Advancement	Some Typical Means	Some Results
Mastering of greater distances with reduction in delivery time and/or cost.	Jet transport aircraft. Helicopters. Terrestrial transport rockets. High-speed rail transport. Ships and freight trains. Oleoducts. Supertankers. Conveyors for pedestrians. Hydrofoils.	Business and tourist travel in the entire world, attaining 3000 miles in 8 hours. Daily freight service by domestic carriers and to international centers. Specialized large-volume transport systems, at dense-traffic conditions; special maintenance equipment for such transport systems.
Travel and activities in new elements: 1 - in space 2 - under water 3 - in Arctic regions.	Space vehicles. Submarines, bathyscaphs, automatic scaphandres. Helicopters, Arctic shelters, public services, railless trains, and life support systems.	Warfare in new environment; defensive, offensive, surveillance, and communications devices. Development of new life support systems. Acquisition of scientific knowledge. Beginning of new commercial operations (for example, communications satellites, meteorological stations).

APPENDIX II

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RISE IN CONTROL OF ENERGY

Field of Advancement	Some Typical Means	Some Results
Much greater magnitude and intensity of available energy.	H bombs, nuclear reactors, nuclear explosives, chemical rocket propellants.	Major evolution in methods of warfare, national defense, strategy, tactics, and international politics. Increase in scientific knowledge. Exotic fuels for power stations. Thousands of new technical demands. Possibilities of major modifications of geographic characteristics.
Energy converted by much smaller quantities and controlled with increased accuracy.	Semiconductors, lasers, microcircuits.	Thousands of elements, products, and new processes. Novel instrumentation. Increase in new demands for technical and scientific data. Reduction in dimensions of numerous apparatus. Manufacturing procedures based on high-energy generation, spark erosion, electrodeposition and electropolishing, ultrasonics, and so on.
Energy produced and converted by new sources and apparatus.	Nuclear reactors, fuel cells, solar cells, magnetohydrodynamic devices, jet engines, thermal ions, static power stations.	Steady pressure in demand for progress in fuels, materials, and control systems. Need for scientific and technical development data.

APPENDIX II (cont'd)

Field of Advancement	Some Typical Means	Some Results
Advancement of high importance with respect to energy stockpiling.	Atomic fuels, fuel cells, nickel-cadmium batteries, hydraulic power by pumps, energy from tides.	Increase in portability. Extension of operating periods without refueling. Reduction in cost price of power production.
Novel techniques for large-scale transportation of power and fuels.	Superhigh voltage transmission lines, liquid propane tankers, hydraulic trains operating on oil, gas, or coal; monorails, cross-country conveyor belts.	Less onerous transport of many propellants. Transport of power and fuels over greater distances. Specialized construction and transportation equipment.

APPENDIX III /105

RISE IN CAPACITY OF EXTENDING AND CONTROLLING THE LIFE OF ANIMATE AND INANIMATE OBJECTS

Field of Advancement	Some Typical Means	Some Results
Modification of living matter and extension of life span, tolerance of extreme climatic conditions, control of growth with respect to proportions and stages; maximization of most valuable parts. Greater resistance to disease and accidents. Suppression of undesirable organisms.	Selective breeding. Development of hybrids and special strains. Special feeding and fertilizers. Prophylactic treatment with antibiotics and chemical products. Control of ambient temperature and humidity.	Greater economic value per unit product. Use period maintained over longer durations and larger range of conditions. Possibility of production in novel regions. Demands for special treatments and equipment.

APPENDIX III (cont'd)

Field of Advancement	Some Typical Means	Some Results
Prolongation of life of perishable foods and other organic products and objects.	Packing methods. Packaging in protective surroundings such as deep-freezing, dehydration, and irradiation.	Increase in shelf life. Minimizing of seasonal effects and limitations.
Reduction in deterioration of natural constitution.	More durable materials. Prophylactic treatment against damage by insects, corrosion, wear, fungi, and other factors. Improvement of structures and projects.	Reduction of maintenance. Prolongation of life. Reduction in number of tasks.

APPENDIX IV /106

RISE IN CAPACITY FOR MODIFYING CHARACTERISTICS OF MATERIALS

Field of Advancement	Some Typical Means	Some Results
Novel properties imparted to existing materials.	Application of chemical and metallurgical knowledge to modification of material properties.	Improvement in properties such as strength, weight, heat resistance, corrosion resistance.
Synthetic materials.	Improvement in control of purity, additives, and procedures. Novel manufacturing processes.	Different-type manufacturing processes and technical qualifications of labor, required by end user. Novel possibilities of product conception.
Combinations of materials for obtaining unique characteristics.	Typical examples: engine blocs of aluminum, replacement of textiles by paper or plastics. Synthetic fibers, rubber, petroleum, and foodstuffs. Glass fiber, prestressed concrete, metal and ceramic compounds	Reduction in cost price of numerous materials and/or finished products.

APPENDIX IV (cont'd)

Field of Advancement	Some Typical Means	Some Results
	(cermets), plywood girders, plastic and aluminum honeycomb structural panels.	

APPENDIX V /107

EXTENSION OF SENSORY CAPACITIES OF MAN

Field of Advancement	Some Typical Means	Some Results
Vision	Radar. Electron microscope. Television. Radioastronomy.	Transport and strategic operations under previously prohibitive conditions of darkness, fog, rain, etc. Capacity to "see" up to about 200 miles. New information on materials, biology, and disease. Novel methods of training, education, and entertainment. Extension of knowledge of the universe.
Hearing	Microphone and amplification techniques: magnetic tape recording.	Radio and high-fidelity phonograph equipment. Use of sound detection for war and police.
Touch	Combination of instrumentation and commands, for identification of infinitesimal or distant conditions and their modification by man.	Slave mechanisms such as servocontrol, servobrakes, aeronautic guidance. Remote control of hydraulic trains. Radio control (guidance systems) of target aircraft or drones, industrial cranes, and special vehicles.

APPENDIX V (cont'd)

Field of Advancement	Some Typical Means	Some Results
Visual, olfactory, auditory, and similar power of discernment.	Instrumentation for detecting infinitesimal quantities and dimensions. Amplification and measuring technique.	High-precision measurements, leading to new scientific data, delicate controls, and safety devices.
Memory (retention of visual and auditory impressions).	Extensive progress in photographic sensitivity and accuracy of reduction. Techniques of duplication (xerography). Direct conservation of vision and sound on videotape, magnetic recording tape, and polaroid photography.	Novel recording capacity and recording studies for science, warfare, technology, sociology, trade. Novel entertainment devices.

APPENDIX VI

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RISE IN MECHANIZATION OF PHYSICAL ACTIVITIES

Field of Advancement	Some Typical Means	Some Results
Production: Direct manual work. Allocation of operations. Maintenance of materials. Assembly. Tests and control. Packing for shipment.	Mechanical tools, computer-controlled tools. Vibration chargers. Truck hoists, cranes, conveyors. Assembly machinery. Electronic, pneumatic, electric, and other control devices. Automatic packing machines.	Greater proportion of machines and larger mechanical investment. Evolution in personnel qualification (usually). Reduction in labor per unit produced. Increase in maintenance (usually). Increase in capacity. Reduction in flexibility of operation (usually).
Distribution: Expedition and reception. Storage.	Truck hoists, cranes, conveyors, automatic grain elevators, automatic maintenance and	More rapid response of the production system to demand.

APPENDIX VI (cont'd)

Field of Advancement	Some Typical Means	Some Results
Loading of transporting means.	control systems for base materials of conveyors and recuperators. Volume pneumatic loading.	
Communications and control: Filing of documents, plans, and correspondence. Recording and assembly of data.	Transport systems by pneumatic tube, reproduction devices, cable television, vertical selective conveyors, transceiver radio stations, dictating and transcribing equipment, teletypes and tele-transcribers.	
Construction and hoisting industries: Excavation work. Mining. Exploitation, foresting, agriculture.	Cross-country conveyors, 100-ton steam shovels, extension of special-purpose vehicles such as tractor shovels, heavy trucks, tractor transports, bulldozers, etc.	

APPENDIX VII

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RISE IN MECHANIZATION OF INTELLECTUAL PROCESSES

Field of Advancement	Some Typical Means	Some Results
Direction of long and complicated mechanical actions.	Command by feedback of treated data. Command by punch cards for channeling of heavy materials. Digital computers. Punch tape typewriters, etc.	Increase in accuracy, reduction in organization delays, decrease in training of operators, need for programers.
Data processing.	Computers and commercial machines for write-in, sorting, manipulating, interpreting, storing,	Reduction of office work. Increased rapidity in preparing documents of all types.

APPENDIX VII (cont'd)

Field of Advancement	Some Typical Means	Some Results
	and read-out of selected data. Mechanical reproduction of selected data, formulas, checks, etc.	Increase in accuracy. Rapidity of preparing resumés of commercial situations.
Problem-Solving.	Solution by computer of complex scientific calculations, investigations, and commercial manipulations. Simulation by computer of military and business problems. Analysis by computer of operations research problems.	Solution of problems impossible to solve by other means. Exploration of complex problems. Assistance in decisions on questions of policy and commercial strategy, or of prime military importance.

RESEARCH, DEVELOPMENT, AND GROWTH /110

G.W.Wilson

In a recent article, Robert A. Solo raised a few important problems on the correlation between Research and Development and economic expansion. However, his arguments contain a few serious weaknesses which cannot be passed over in silence because of the importance of the subject matter. I wish to correct here a few of the fallacious statements made by Solo.

The main error in his article resides in the more or less high-handed treatment of certain statistical estimates that constitute the "raison d'être" of Solo's analysis. I am thinking particularly of the attacks he makes on accepted ideas (according to which an intensification of Research and Development contributes to the increase in rate of economic expansion), attacks that lead Solo to conclude that "there exists absolutely no proof of a definite correlation between the rate of national economic expansion and national expenditure for Research and Development". This is in flagrant contradiction to the conclusions drawn by E.F.Denison who attributes 20% of the increase in production recorded between 1929 and 1957 to "the progress in science and its applications" (Bibl.23), with Chapter 21 of his book directly concerning this debate. The /111 argument by Solo is based essentially on a calculation of the annual rate of evolution of the real gross domestic product of private economy and on the index of the correlation established between expenditure for Research and Development and the national income. In the document 1A, produced by Solo, numerous elements which cannot be compared should be singled out.

Primarily, the productivity figure is given in real value (taking amortization into consideration) and concerns the private sector of the economy, whereas

the R & D index covers Research and Development by public as well as by private means with respect to the national revenue, visibly expressed in nominal dollar value. One need not be an expert in statistics to detect the inaptness of the comparison between the two series of figures, taken from different epochs. In fact, the first series allows for the evolution of prices and amortization but concerns only private domestic economy whereas neither the numerator nor the denominator of the other series have been corrected, with the denominator referring to the totality of national economy less amortization.

In addition, it is quite obscure why one should expect that the rate of evolution of productivity (i.e., the real gross domestic product of the private sector divided by man-hours) should increase with Research and Development, since - at equal rate of evolution - greater growth in absolute value would be obtained starting from increasingly higher figures. Obviously, if this is /112 measured in production by man-hours, productivity has almost doubled since 1929. According to the data by John W. Kendrick, used by Solo, which take the figures of 1929 as the index 100, productivity reached an index of 193 in 1957 (Bibl.24). Thus, there is a definite direct relation between productivity and Research and Development, such as measured by Solo.

Making use of annual modifications in the productivity percentage is particularly misleading, since such modifications are intimately connected with the direction in which production evolves, which varies considerably from year to year. The true fact is that, in general, the evolution of production is superior to that of the paid man-hours (or employees), which makes temporary fluctuations in productivity an almost automatic phenomenon. Considered over brief periods of time, productivity is subject to so many diverse influences (namely, anything that has any influence on paid man-hours and on production) that it is

particularly fallacious to compare the modifications of this ratio to just any factor. This is even more true of the expenditures for Research and Development whose effect, as is generally admitted, makes itself felt on a long-term scale. Thus, it is not surprising that Solo was unable to discover any correlation between the two investigated series, even supposing that these were at all comparable which is by no means the case.

However, if his R & D index is referred to the productivity instead of to the modifications of productivity, it will be found that - since 1929 - Research and Development has increased by about seven times whereas productivity itself doubled. Can one deduce from this that R & D has no noticeable effect on /113 this gross expansion index? Obviously, no. Nevertheless, the differential rates of economic expansion, strictly speaking, could just possibly mean that Research and Development is subject to nonproportional yields, which would not contradict Solo's thesis. In fact, so far as he is concerned, the variable nature of R & D may actually inhibit expansion. However, several other explications are equally possible. For example, in view of the fact that productivity depends largely on the production volume, the crisis of 1930 and the laggard resumption of real production after 1950 would explain the general slowdown of the growth rhythm of productivity. In addition, the "meager result" of Research and Development may be attributed to the recrudescence of other antagonistic forces which R & D compensates in part: slipping of the production composition from a high-productivity sector to a low-productivity sector (from durable consumer goods to services); disproportionate yield possibilities with regard to natural resources; underestimates due to the impossibility of accurately measuring the modification in quality by all production indices; and alleged decline in inventive spirit. Personally, I give little credit to these explanations

but they certainly are just as plausible as Solo's statements who deduces from poorly selected sources that R & D has no definite correlation with expansion. Peter F. Drucker recently deplored the "poor policy followed at present by numerous American firms in the domain of industrial research" (Bibl.25). Similarly, James Brian Quinn and James A. Mueller emphasized important problems referring to the conversion of Research and Development into tangible results; this might possibly furnish a logical explanation for the apparent decline in /114 the role of R & D in productivity (Bibl.26).

In addition, the data used by Solo exhibit serious weaknesses. Evsey D. Domar (Bibl.27) violently criticized the estimates by Kendrick which, as mentioned above, yield no satisfactory explanation for the evolution of quality. The estimates with respect to R & D are even more fragmentary. It is well possible that the first R & D figures had been grossly underestimated on the whole and, to the extent to which greater interest focused on Research and Development and to which this field became more specialized in "the industry of discovery", activities that were previously debited to current expense were then transferred to the account of Research and Development.

Recently, Yale Brozen has published a correction factor of 40% for 1921, of 33% for 1921 to 1933, and of 16% for 1938 with respect to the data given by V.Bush before 1940. He also introduced a supplementary correction of 20% to permit "a more realistic comparison with data of later than 1940" (Bibl.28); see also Denison, loc. cit. p.239.

In addition, it is quite difficult to define what R & D actually does "discover". Should the creativity within a given firm be placed into this category? Adam Smith already attributed an important portion of the growth of /115 productivity to professional creativity and to the development of initiative

resulting from the division of work. There is no doubt that, today, these two factors contribute much less to discoveries and innovations. However, creativity within a given enterprise always involves a professional qualification, and its advantages are far from negligible (Bibl.29). One could ask to what extent this creativity can be justly allocated to Research and Development. If we are concerned at all with the expenditure involved in the growth of productivity, it would be basically wrong not to take this into consideration. Naturally, another point not to be neglected is that of the funds invested in on-the-job training.

An evaluation of the portion of expenditures debited to in-service training, which should really be allocated to the account of Research and Development, constitutes an extremely delicate problem; however, it is obvious that not only research contracts let to universities are involved here. Similarly, Solo was entirely wrong to exclude expenditures attributable to public health, under the pretext that they are unrelated to expansion (Bibl.30).

This distinction between expenditures considered as directly favorable to productivity and those that are not directly obvious, is in itself arbitrary and depends on a large number of variables. A classification into various forms of expenditures favorable to the growth of productivity is even more arbitrary. The truth is that the data concerning Research and Development are not rigorous at all and are empirically incoherent. In time and after more systematic /116 studies, there is no doubt that more reliable series can be developed; however, for the moment one should guard against building general conclusions on such a fragile base. According to the statements made by Simon Kuznets: "If we wish to study creative activity, the wrong idea can be easily created by using incomplete estimates or estimates so encompassing that the expenditure, referring

to creative activity, will be reduced to an extremely small and probably variable part of the total" (Bibl.31). However, the study made by Solo on the correlation, or absence of correlation, of R & D with expansion presents serious problems of a theoretical order, in addition to the uncertainties resulting from the data used. Primarily, he defines a portion of the total of Research and Development, which already is arbitrarily defined, as being "oriented toward expansion" by stating that this portion represents the method of planning and organization adopted by technicians in solving problems of private industry, such as improvement of techniques and products. Thus, he maintains that, by definition, medical, military, space, and similar research, which does not form part of research by private industry, is not oriented toward expansion. On the basis of these definitions, he contests the correlation existing between non-private R & D (comprising also the sector of private R & D which has to do with military and aeronautic investigations) and the "accrued production obtained /117 at the price of the same human effort, of goods and services which form the very substance of economic expansion".

It is obvious that this constitutes an extremely narrow conception of economic expansion. First of all, Solo compares the gross national product in its totality with Research and Development, after which he concerns himself only with that portion of the gross national product which, in a certain sense, concerns the private sector or, expressed in other words, he passes a qualified judgment on the composition of the gross national product and only treats what he vaguely calls "the substance" of expansion. However, on the social level and on that of the services, this distinction appears quite subtile. In fact, it is by a tautology that he attempts to "prove" that a large portion of Research and Development has nothing to do with expansion. He defines expansion with respect

to private industry but, at the same time, defines Research and Development oriented toward expansion depending on whether this R & D is or is not intended for private industry. Based on such definitions, it is naturally not difficult to "prove" that Research and Development, intended for astronautics and armament, contributes nothing to expansion, again based entirely on the same fallacious definitions. Nevertheless, it is certain that, if we consider the composition of the gross national product as such, including the production of the military sector, expansion itself implies less investment per unit of gross national product, independent of its composition, unless one would choose to venture into the maze of the social composition of the gross national product. Even in this case, this would by no means indicate that nonprivate production would be the only fraction of general production to be excluded, as would have to be admitted even by a reader opposed to the views aired by Galbraith in his book "Era of Opulence". Thus, the distinction made by Solo between Research and /118 Development oriented toward expansion and Research and Development not oriented toward expansion is even less convincing and full of qualified opinions.

Despite this criticism, I do recognize that the paper by Solo has considerable value. First, it is of some use to re-emphasize the importance of studying a given unit from the viewpoint of its composition rather than from its totality. There is no doubt that government-sponsored R & D has removed the overall composition of Research and Development from a predominantly commercial orientation. In addition, the advantages that nonprivate Research and Development is able to offer to private industry are not spontaneously or automatically exploited by the various enterprises, for which reason a deliberate effort must be made to establish new exchange media for organizing "relations within the social community". In agreement with Solo, I also believe that the universities are

capable of becoming efficient intermediaries if they tackle the problem head-on. The exchange between governmental R & D and private enterprise could take place over the intermediary of universities, as we are actually doing at the Aerospace Research Application Center of the University of Indiana. One of the best means for preserving the dynamics of private American enterprise is to eventually allow it to benefit from the results of government-sponsored R & D over the intermediary of universities, under a form still to be defined.

Solo terminates his article with an analysis that reveals the crucial problems and which, in my opinion, indicates the road to follow for finally arriving at a better comprehension.

However, Solo was unable to distinguish clearly between the basic correlation existing between Research and Development and expansion nor to demonstrate the nature of the problem. This is not the first time that a poorly substantiated analysis has permitted to derive relatively valuable conclusions and suggestions. /119

REPLY TO G.W.WILSON /120

R.Solo

In the July-August issue of the Harvard Business Review, Prof. George Wilson, according to his own definition, attempts to "correct some fallacious statements" that he took from my article published in an earlier issue.

I have studied Wilson's letter, but have found it impossible to find the exact statements to which he objects. I have made an effort to understand his arguments so as to permit me to answer objectively, but I must say that I am entirely unable to recognize true arguments here. The best I can do is to present and comment on what appears to me to have been the cause of his objection.

Prof. Wilson concentrates his attack on the comparison (see Fig.1A of the article)* established between the annual evolution of productivity (production by man-hour) and the portion of the national income allocated each year to Research and Development, as well as on the statement according to which "absolutely no proof exists for a definite correlation between the national rate of economic expansion and the expenditures allocated to Research and Development".

Wilson establishes no definite relation between the national expenditure for Research and Development and the annual rate of expansion, no more than he suggests the existence of a definite correlation between these figures, as /121 they are given. However, his first objection is that this conclusion "is in flagrant contradiction to the conclusions drawn by E.F.Denison who attributes 20% of the increase in production recorded between 1929 and 1957 to the progress

* See Research Report No.1 GRD (Cahier d'Études, No.1; Groupe d'Études "Recherche et Développement".

of science and its applications".

The conclusions drawn by Denison, correct or not, are completely irrelevant here. When I speak of Research and Development, I do mean definite work, evaluated and communicated by the National Science Foundation, rather than primary, secondary, or superior education, dissemination of information, recent progress, etc. which Denison all lumps into the result obtained by him.

What Wilson understands by Research and Development is in no relation to the meaning I have given to this term and which, incidentally, is the current and official definition. For him, it is obvious that R & D covers any form of activity that leads to a growth of productivity. This induces him to make the following statement:

> "In addition, it is difficult to establish what Research and Development truly constitutes. Should one include creativity in the enterprise itself? Adam Smith already attributed an important portion of the growth of productivity to professional creativity and to development of initiative resulting from the division of work. There is no doubt that, today, these two factors contribute much less to discoveries and innovations. However, creativity within a given enterprise always involves a professional qualification and its advantages are far from negligible. One could ask to what extent this creativity can be justly allocated to Research and Development. If we are concerned at all with the expenditure involved in the growth of productivity, it would be basically wrong not to take this into consideration. Naturally, another point not to be neglected is that of the funds invested in on-the-job training."

It is difficult to see why all expenditures, allocated to growth of pro- /122
ductivity including "funds invested in on-the-job training and public health",

should or must be grouped with the R & D account. This is by no means the sense given by me to this term, and whoever is of an opposite opinion is unable to interpret what I have written. There is another deep reason for this misunderstanding. This is the fact that I obviously have not been able to make Prof. Wilson understand my reasoning. In any case, he seems to forget completely the goal I had in writing the article. For example, Wilson specifies that the productivity evolution index and the index of R & D expenditure contain "numerous elements which are not comparable". It is certain that a comparison has value only with respect to the intended goal. I thought to have sufficiently defined that the goal of my comparison was to verify a generally accepted concept, namely, that a direct relation, obvious with respect to cause and effect, exists between the actual rate of expansion of the national economy (over the intermediary of the rate of growth of productivity) and the portion of the national revenue actually invested in Research and Development. In fact, I raised the question whether this should always be so. If an attempt is made to verify the hypothesis according to which an obvious relation exists between the portion of national income actually invested in Research and Development and the true rate of productivity growth (such as it is traditionally defined and published), then it is logical and obvious that the portion of the national revenue actually invested in Research and Development and the true rate of productivity growth are comparable and, in fact, that such a comparison is mandatory.

At two occasions, Prof. Wilson suggested in his letter to correlate the portion of national income, actually invested in Research and Development, with the productivity in absolute value rather than with the rate of evolution of productivity; this would imply that he and I have a widely differing conception of the manner in which Research and Development influences the productivity. /123

According to me, the important effect of R & D consists in the creation of new techniques, new products, and new procedures which would mean that the logical correlation resides in the evolution of productivity as a function of the evolution of technical production bases. Thus, an extension or an improvement in Research and Development will automatically accelerate the rhythm of growth of productivity. In turn, the actual productivity in absolute value is not the result of Research and Development but rather of inventions, discoveries, and cumulative technical progress over the ages (going as far back as the invention of the wheel and the discovery of fire). It is readily conceded that, even if Research and Development should stop completely, the absolute value of productivity would not diminish by much.

Nevertheless, Prof. Wilson apparently wishes to prove that the absence of an obvious and well-defined correlation between the annual investment rate, attributable to Research and Development, and the annual rate of expansion does not necessarily prove that no relation of cause and effect exists between Research and Development and economic expansion. For example, Wilson writes:

> "In addition, the 'meager result' of Research and Development can be attributed to the recrudescence of other antagonistic forces which R & D compensates in part: slipping of the production composition from a high-productivity sector to a low-productivity sector (from durable consumer goods to services); disproportionate yield possibilities with regard to natural resources; underestimates due to the impossibility of accurately measuring the modification in quality by all production indices; and alleged decline in inventive spirit."

Again, my reasoning seems to have completely escaped Prof. Wilson. I /12/4 wrote:

"What is the consequence of this conclusion? This by no means signifies that certain firms would not benefit from Research and Development or that these might not have been at the origin of the creation of large industry. Quite the opposite is true. It also does not mean that R & D sponsored by Federal Government did not contribute to economic expansion. However, it might well mean that other indeterminate obstacles have hindered expansion and canceled the increasing advantages of Research and Development."

Never did I deduce from this that "Research and Development has no correlation with expansion". I simply believe that there is no need to formulate this correlation as an axiom. Actually, I did write:

"The true facts prove that the influence of national efforts in Research and Development on the economic expansion will have to be verified. It is not sufficient to assume a priori that a correlation exists between R & D and the growth in industrial productivity. It would be necessary to investigate Research and Development in more detail to define the extent to which this constitutes a real factor (possibly to be improved further) of technical progress and economic expansion."

Professor Wilson reproaches me of differentiating between Research and Development oriented toward economic expansion of private industry and Research and Development oriented toward military interests, space conquest, and public health. He sees in this a "qualified judgment", but I cannot perceive why the statement that a certain R & D sector belongs to the domain of expansion should be more of a "qualified judgment" than the statement that another sector, sponsored by the National Institute of Health, belongs to "the domain of public health" or that a third, sponsored by NASA, belongs to the "interests of space"!

Wilson also wrote:

> "It is by a tautology that he attempts to 'prove' that a large portion of Research and Development has nothing to do with expansion. He defines expansion with respect to private industry but, at the same time, de- /125 fines Research and Development oriented toward expansion depending on whether this R & D is or is not intended for private industry. Based on such definitions, it is naturally not difficult to 'prove' that Research and Development, intended for astronautics or armament, contributes nothing to expansion, again based on the same fallacious definitions."

I am afraid Professor Wilson has completely misunderstood the articulation and the final goal of my reasoning. The article in question was entitled "Integration of Military Research and Development with Economic Expansion". Basically, the paper concerned the phenomenon of "osmosis", i.e., the communication to private industry of results from military aerospace R & D, susceptible to increased industrial production. Far from excluding a possible contribution to economic expansion made by Research and Development in aerospace and armament, my definitions partly explained the manner in which this contribution could proceed and actually does proceed. I emphatically state that Research and Development in the aerospace and military sector has a positive as well as a negative influence on economic expansion. I can give weighty examples, such as the development of electronic computers, which prove that economic expansion has benefited from military R & D. The principal objective of my article actually was to explore the means permitting aerospace and military R & D to impart greater benefits to the productivity of private industry.

Professor Wilson accuses various statistics on Research and Development,

such as those published by the National Science Foundation, of being "very little rigorous and empirically incoherent". Just as Yale Brozen, he maintains that the first data developed by Vaunever Bush with respect to Research and Development must be corrected, in view of recent studies (which had actually been /126 done relative to my own data). Wilson picks up the criticism by Evsey Domar relative to the theoretical studies by Kendrick on productivity which, according to him, do not make sufficient allowance for the evolution of quality; in my opinion, these criticisms reduce to condemning any use of figures of the gross national product or of the national revenue as indices for economic activity or relative prosperity. He claims a system of national compatibility and thus a correlation of production per unit work, i.e., a productivity index which would encompass not only the real value of commercializable products per unit work but also the power of bombs, the force of thrust, and the accuracy of guidance of spacecraft as well as the pure scientific knowledge, evaluated in production per unit work. This is more than ambitious; however, for my part, I do not consider myself worthy of attracting these Jupiterean lightning bolts. If Prof. Wilson desires to pursue the debate on such subjects, I would suggest that he tries his lance on other dragons.

ANALYSIS OF THE "ROLE AND EFFECT OF TECHNOLOGY ON THE NATIONAL ECONOMY" OF THE UNITED STATES

/127

J.C.Arinal

The United States and, more particularly, the Federal Government, make increasingly greater efforts and investments in the field of Research and Development. National defense and the conquest of space are the main beneficiaries.

However, various important imbalances result from this, which should be demonstrated and resolved if possible:

- imbalance between the activity sectors defined above and the essentially economic sector;
- imbalance between the various geographic regions;
- imbalance between enterprises that benefit from Government R & D and those that do not benefit;
- imbalance between large enterprises and small ones, large universities and small ones.

Below, we present an analysis of the hearings on these problems*. These debates were organized under the auspices of the American Senate in May and /128 June 1963, presided over by Senator Humphrey for the :

"Subcommittee of the Select Committee on Small Business".

At this occasion, various government officials, representatives of universities and of the business world, paraphrasing an exposé that they had previously submitted, were heard.

We will not pick up the enumeration of the problems in the order in which

* The basis used for this paper is the exact transcript of the oral debates, which were later supplemented by written exposés submitted by the participants (Bibl.32).

they appeared during the hearings, but rather will attempt to give an overall presentation and a general and coordinated view.

PART I

To produce an impression of the importance of Research and Development in the United States, we will give some figures taken from the depositions made during the hearings.

TABLE 1

FINANCIAL MEANS OF RESEARCH AND DEVELOPMENT, 1961-1962
(National Science Foundation)

(in million dollars)

Total Resources	14,742
Allocation of resources - Federal Government - Industry	 2,090 10,872
Origin of Financing - Federal Government - Industry	 9,650 4,707
Share of the Federal Government - in R & D financing - in industry	6,313

In 1961, the Federal Government distributed: /129

667 million dollars to companies with less than 5000 employees;

5646 million dollars to companies with more than 5000 employees.

There were, in January 1962	There will be, in 1970
400,000	625,000 scientists
900,000	1,400,000 engineers.

In January 1962, a total of 319,800 scientists and engineers worked full /130 time on R & D problems in industry, of which:

70,200 in companies with less than 5000 employees;

249,800 in companies with more than 5000 employees.

The number of scientists and engineers per 1000 employees, working in R & D in 1961, varied as follows:

from 3 in the textile and garment industries

to 52 in electric equipment and

to 101 in aerospace and missile industries.

TABLE 2

DISTRIBUTION OF FEDERAL AID AMONG COMPANIES HOLDING R & D CONTRACTS

Firms Classified in Accordance with the Importance of their R & D Programs	Percentage of Total, Realized in all Industrial Firms			
	Total Resources	Resources due to Federal Government	Sales	Employment
4 Res. companies	22	32	4	5
8 Res. companies	34	45	10	11
20 Res. companies	54	66	17	19
40 Res. companies	69	84	24	26
100 Res. companies	81	92	40	40
200 Res. companies	88	96	52	50
300 Res. companies	91	97	60	57

TABLE 3

SCIENTIFIC RESEARCH IN AMERICAN UNIVERSITIES
(Fiscal Year 1962)

	Funds Allotted to Basic Research	Funds Allotted to Research and Development	Total of Funds Received per University and its Research Centers under Contract
Department of Defense	96	194	402
NASA	28	31	76
Atomic Energy Commission	40	57	212
Public Health	104	268	505
National Science Foundation	90	90	99
Others	12	48	270
Total	370	688	1564

(In million dollars) Source: BOB - NSF

PART II. PRESENTATION OF THE PROBLEMS RAISED DURING THE HEARINGS /131

1. Theoretical Problems

What is the signification and the goal of the enormous effort made in our era in the domain of Research and Development?

How can economic growth be defined?

Is it possible to find a correlation between economic growth and R & D investments?

Can one conceive the social modifications engendered by the introduction of new technologies?

Can one, at present, find a correlation between underemployment and educa-

tional level?

How can the consequences of a theoretical discovery, made today, for the economic structure of tomorrow be defined?

How can the evolution of this structure, as a function of technological conversions expected in the near future, be predicted?

Does the evolution of technology make us less dependent on natural resources?

Is it necessary to predict at present the replacement of basic products we are using today?

How can one evaluate and measure the resistance of the social body to the introduction of a new technology?

Is it possible to establish a code permitting to judge the value of an innovation?

2. Teaching and Training

Is teaching and in-service training adapted to the new forms of economic society?

How does education spread within the nation? /132

Is the training of engineers too much oriented toward research and not sufficiently toward practice?

How can the engineer trainee be given a sense of reality?

If the US suffers from a lack of technicians, intermediary between scientists and laborers, how can this state of affairs be remedied?

How can it be prevented that technical training will be rapidly obsoleted by the introduction of new techniques?

Does the engineer, in his work, make use of the knowledge acquired at the

university?

Could the class of technicians, of which there is a dearth at present, be recruited from the less privileged population strata, such as colored people in particular?

Does the US properly make use of the potential represented by its female population? Is this population not captive of the stereotype concept of "woman"?

How can it be avoided that scientists live in an ivory tower?

Could a generalized superior education be expected to produce a large number of superior minds and, in particular, of inventive minds, and to what extent?

What effort must be made for developing minds able to direct and organize the economic life of the nation?

Does the present effort in Research and Development disfavor basic research?

3. Dissemination of Information /133

The enormous investment in R & D leads to a proliferation of technical and scientific publications and, for the researcher, to the obligation of publishing. To what extent does this state of affairs interfere with:

- the pursuit and outcome of research undertaken;
- the teaching of accomplished results to students;
- the dissemination of important results obtained?

How can it be avoided that closed circles of producers and consumers of innovations, with links to the outside world, are created?

How can duplication of publications be avoided?

How can information be disseminated from the military sector to the civilian sector, from one industrial sector to another, from one branch of an individual

firm to another?

How can the general public be made to understand the significance of a given innovation?

4. Federal Government

The part taken by the Federal Government in R & D investments increases by leaps and bounds. Simultaneously, the problems to be solved become more numerous.

How can the priorities of governmental objectives be classified?

In particular, has the relative significance of defense, space conquest, and economic growth been properly evaluated?

Is it possible to do all this and not risk weakening the nation by excessively increasing the effort made in the domains of defense and space?

Does the US always have to be in the forefront of progress in all fields /134 or can it leave to other nations the task of pioneering and blazing the way, and then later profit from the experience acquired in this manner?

Should Government plan its investments in Research and Development? From the viewpoint of what policy? Should this planning be indicated only in rough outlines or, conversely, should it be worked out in minute detail?

What governmental mechanism can be used for counteracting certain detrimental phenomena due, in part, to the present form of R & D investments? How can it be prevented that certain regions are dangerously depleted in intellectual and industrial resources? That certain conventional industries suffer excessively from the preference given to new industries? That the young and competent elements of the agricultural sector do not leave this sector for other, more favored, fields?

Are the institution of such planning and the creation of such regulatory mechanisms compatible with the notion of free enterprise, characteristic for the US?

Does the present creation of a new class of scientists and engineers working on government projects and thus, with respect to other occupations and because of the type of their work, losing the capability of taking risks and of individual enterprise, constitute a threat to the society of free enterprise?

Does the search for new natural resources (particularly, the search for water in the western portion of the United States) oblige the government to plan and organize the development of other economic factors, such as urbanization, settling of industries, recreation areas, rest homes, etc.?

How can one prevent the creation of Federal agencies in all domains from becoming a brake to economic growth? What dimension should be given to such /135 agencies and how should they be managed?

How can the institutional, legislative, financial, and political environment be measured and modified so as to permit an improved flow of scientific inventions to the national economy?

What is the long-term value of the method which, for protecting the American economy from the invasion of competitive foreign products, erects protective tariffs?

5. Small and Medium Enterprises

Small and medium businesses are the backbone of the American economic structure. For these, the influx of investments - specifically, Federal - in Research and Development is a major problem. Some businesses are created and others vanish.

How can the new dominant factor of the significance of a given firm be measured, namely, its intellectual capacity?

Is the cost of modern research prohibitive for most of the small and medium business enterprises?

Is there a threshold beyond which a given enterprise can innovate and prosper? How can this threshold be defined?

What is the percentage of inventions generated by small business enterprises?

Is the personnel managing small and medium business competent to handle the task imposed on it by contemporary society?

6. Relations between Federal Government and Business

Does a transfer of innovation from the military and space sectors to the economic sector exist? What is the extent of such "overflow"? What type of enterprise profits from this?

Can a small business, wishing to improve its situation, undertake the necessary research on its own initiative or should it appeal to the Federal /136 Government?

If such business solicits a research contract from the government, to what extent must it be able to predict the mode of such research and its economic consequences?

What are the criteria on which Government, and particularly the Department of Defense, can base itself in awarding research contracts to business?

Does the proposal submitted by an enterprise, soliciting Federal contracts, risk being economically fatal to this business if it is not awarded a contract?

Does the Federal Government award a research contract to a given enterprise

because this business has available an industrial and intellectual capacity of a sufficient level or does the business reach such adequate industrial and intellectual level because it has been given a Federal contract?

If Government and enterprise cooperate in ensuring the development of a certain technology, what part should Government take in the commercialization of the resultant products?

Does the concentration of Federal research and large investments in certain privileged and central industrial sectors carry the risk of diverting a large number of scientists and engineers from small business, which needs such personnel?

How can Government resolve the permanent conflict between the Department of Justice which prosecutes the formation of industrial trusts and the Department of Defense or the Treasury Department which favor such centralization?

How can the spirit of enterprise, and thus the very existence of small business, be protected?

In particular, should the patent system be modified? Should a new fiscality be created?

7. Link between University and Industry /137

How can the distrust of small business toward universities be eliminated?

How can the university be integrated with the regional economic life?

Does a correlation exist between regional R & D and the Educational level in that region?

Does the small university, just as the small business enterprise, suffer from the enormous investments by Government in certain privileged regions where the large universities are located? On the other hand, might this habit of

concentrating researchers in a few very large research centers be more detrimental than beneficial to research itself?

How can the university assist business to understand the end toward which it is profitable for business to cooperate?

PART III. QUOTATIONS FROM THE MINUTES OF THE HEARINGS, IN SEQUENCE

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(The Numerals Following the Quotation Correspond to the Classification of the Problems, Suggested by us above in our Subheadings)

"... It is extremely difficult to establish a correlation between the expenditure for Research and Development on the one hand and no matter what other phenomenon on the other hand ..." (Subh.1)

J.Rubel p.16*
Assistant Secretary of Defense

"... The Federal Government is in the process of changing the United States into a vast intellectual desert by concentrating R & D contracts in limited geographic zones ..." (Subh.4)

Senator Humphrey p.19

"... Numerous examples demonstrate that it frequently needs an entire generation before some novel device is used on a large scale ..." (Subh.1)

J.Rubel p.25

"... I have asked: What have you, the manager of this business, done to familiarize all branches with an innovation realized in one of them? ... Generally, I received the same answer: Very little!"

J.Rubel p.26

"... I frequently have had the following conversation with members of the Government:

- Why not award a contract to such and such enterprise?

* Page numbers refer to pages of the Minutes.

- Because they cannot manufacture what we require at a reasonable cost and they do not have the necessary competence; there is another business enterprise that possesses this competence.
- Why does this enterprise have such competence? Is it not because you have awarded it this particular contract?" (Subh.6)

Senator Humphrey p.29

"... Many people believe that the efforts in R & D, made in the private /139 industry sector, are retarded by those made in the public sector and that this cannot be compensated by an eventual 'overflow' from the military and space sector ..." (Subh.3)

J.Rubel p.30

"... Numerous achievements considered to be a success in the public sector would have been rated as catastrophes if they had been performed in the private sector. They would have led their promoters to ruin before ever having done some good ..." (Subh.1)

J.Rubel p.35

"... The 'overflow' is too uncertain, too inefficient, and too long-term ..." (Subh.6)

J.Rubel p.35

"... This leaves the question open: How can this novel social invention (Federal R & D) be utilized outside of the sectors to which it is presently confined ..." (Subh.4)

J.Rubel p.36

"... Do we really need more economic growth? What sort of growth? In what sectors? And how can it be measured? ..." (Subh.1)

J.Rubel p.37

"... Several diagrams ... seem to suggest that Federal R & D is more harmful than beneficial from the viewpoint of economic and industrial growth ..." (Subh.1)

J.Rubel p.42

"... Government support can facilitate introduction into the market of techniques and products that are not yet competitive ..." (Subh.6)

J.Rubel p.46

"... Various innovations in management have been realized by joint initiative of Government industry ..." (Subh.6) /140

J.Rubel p.51

"... For a given community in a given region, I am certain that an economic analysis should form the basis for developing a plan for this community ..." (Subh.1)

Dr.Hobson
Vice President
Southern Methodist University, Dallas

"... We do not sufficiently favor the Institutes for Applied Research ..." (Subh.4)

Dr.Hobson p.60

"... In what is known as underdeveloped nations, it is easy to find a large number of persons with high-level diplomas but it is impossible to find a foreman ..." (Subh.2)

Senator Humphrey p.61

"... In numerous regions, the business community wants to have nothing to do with university representatives. Its own propaganda has persuaded it that these people have no practical mind. It does not want to be bothered with it ..." (Subh.7)

Senator Humphrey p.65

"... Frequently, certain industrialists will talk to me and say: We want nothing but a contract with the Government ..." (Subh.5)

Senator Humphrey p.66

"... I believe that we have too large a multiplication of contracts, reports, etc. ..." (Subh.3)

A.Kramish p.87
Rand Corporation

"... Planning is a dirty word ..." (Subh.4)

G.Simon p.99
Cambridge Research Institute

"... Frequently, we begin hearing the following questions: /141

1) Is it better for a small business, that wants to make use of the results of Federal R & D, to look for a Government contract or to let others do the job?

2) If a small business enterprise wishes to penetrate into a new technological field, should it undertake its own Research and Development or should it look for a Government contract?

3) Why are scientists and engineers not more creative, so that R & D will become more profitable? ..." (Subh.5, 6)

G.Simon p.100

"... Frequently, in small business enterprises managed by engineers, research is centered on fields that are in the personal interest sphere of the managers rather than in the sphere of the available market! ..." (Subh.5)

G.Simon p.100

"... Most innovations of major economic importance originated mainly from sources exterior to the industrial branch to which they contribute, namely from independent inventors, small enterprises, foreign technologies, and specifically from an invasion of this industry by firms already solidly established in other industrial branches.

The causes of the main problems are as follows:

- a vicious circle of small profit and small expenditure in R & D;
- the swamping of industry with too many links in the chain of innovation and too many firms below the size required for innovation;
- lack of drive for enterprise, lack of competence, and scarcity of models ..." (Subh.5)

Dr. Schon, Off. Tech. Serv. US Dept. Comm. p.106

"... In my opinion, on our return from the moon, we will have an economically depressed nation incapable of sustaining its military power and its space /142 prestige because of the fact that, today, we allocate a disproportionate part of our researchers to these projects ..." (Subh.4)

J.D.Gurian p.107
National Integrated Systems
& Facilities Inc.

"... The small business enterprise is confronted with a new form of trade: acquisition of the necessary intellectual resources. How can the group of small enterprises enter in competition with the French Government? ..."

J.D.Gurian p.112

"... I will continue to plead for the establishment of a carefully studied Plan of Research instead of establishing two or three general lines to be followed ..." (Subh.4)

Dr. Fisher p.125
Resources for the Future Inc.

"... Have you made no recommendation for improving the structural organization of our Research and Development agencies? ..." (Subh.4)

Senator Humphrey p.126

"... In our study, we came to the conclusion that the Department of the Interior should improve the coordination of its R & D programs ... however, the techniques and mechanisms to permit this did not exist ..." (Subh.1)

Dr. Fisher p.126

"... One of the greatest problems in American agriculture is to furnish the farmer with means for adapting himself to the technological evolution while still preserving the essential characteristics of the family farm ..."

N.Koffsky p.132
Economic Research Service
U.S. Dept. of Agriculture

"... The rapid technological evolution in agriculture has created serious problems of adaptation ... There are numerous farmers who do not have the /143 financial or other resources to draw some benefit from the technological revolu-

tion in agriculture ..."

N.Koffsky p.136

"... In describing the manner in which men and women, in our society, distribute their efforts, you will have defined our culture ..." (Subh.2)

Dr. Bolt p.154
National Science Foundation

"... There has been a lack of respect for women that have a profession. One admires the beauty, the grace of women, but not their professional competence ..." (Subh.2)

Senator Humphrey p.155

"... It is necessary to find a means for increasing the education of those sections of the nation that are below average ..." (Subh.2)

Dr. Bolt p.162

"... We need an adaptable and intellectually flexible society. It is impossible to predict accurately what NASA or any other program may require in 1975 ..." (Subh.2)

Dr. Bolt p.164

"... We are attempting to link R & D, in a certain geographic zone, with the different economic variables ..." (Subh.4)

Dr. Perlman p.166
National Science Foundation

"... Would the textile industry not be better off if, instead of claiming special tariffs and quotas, it made an attempt at a research effort ..." (Subh.6)

Senator Humphrey p.167

"... It must be acknowledged that automation is beneficial, since it increases productivity; however, for profiting from this productivity increase and for avoiding harmful effects, it is necessary to create individuals having the competence required by a constantly growing economy ..." (Subh.2) /144

Dr. Hollomon p.182
Assistant Secretary of Commerce

"... One of the dangers that I can foresee is that each profession tends to

create a closed organization ..." (Subh.1)

Senator Humphrey p.185

"... The entrepreneur and the profits he can make often are the catalysts for the entire process of introduction of a technological change ... Also, to promote such introduction that benefits economic expansion, it is necessary to create an environment that stimulates and promotes the spirit of enterprise ..." (Subh.5)

Dr. Hollomon p.191

"... Government and industry, in cooperation, must ensure the development of technology that industry can utilize for the creation of new goods. However, there is no need for Government to intervene in market decisions, in place of the individual enterprises. Market decisions must be taken by those that assume the risks. If not, Government will destroy all initiative and the market economy ..." (Subh.6)

Dr. Hollomon p.192

"... We are creating an entire generation of engineers and scientists who will know no other but work for the Government ..." (Subh.4)

M.Morse p.195
Cryonetics Corporation

"... A small business enterprise has no more chance in the game than a snowball in hell. When 80% of the brains of the country are concentrated in /145 350 enterprises and when, among the five million private enterprises in existence, more than 200,000 possess industrial installations, the odds are against us ..." (Subh.5)

Senator Humphrey p.211

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